Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 07 Jan 2024
Revised 11 Jan 2024
Accepted 15 Feb 2024

Natural Resources for Human Health 2024, Vol. 4 (4): 544-551

KEYWORDS:
root canal treatment; coronal leakage; coronal restoration; apical periodontitis; periapical healing; timing; restoration quality

The Effect of Timing and Quality of Definitive Coronal Restoration on Periapical Healing Following Root Canal Treatment

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ABSTRACT: Root canal treatment aims to eliminate intraradicular infection and to prevent reinfection so that apical periodontitis can heal. While most attention has traditionally been directed to the technical aspects of cleaning, shaping, and obturation, the coronal seal provided by the definitive restoration is increasingly recognised as an equally important determinant of long-term outcome. This review examines the available laboratory and clinical evidence on how the interval between obturation and placement of the definitive coronal restoration (timing), and the technical adequacy of that restoration (quality), influence periapical healing after root canal treatment. Laboratory studies consistently demonstrate that an obturated root canal exposed to the oral environment can be recontaminated by saliva and bacteria within days to weeks. Cross-sectional radiographic surveys and systematic reviews show that teeth with both an adequate root filling and an adequate coronal restoration have the highest prevalence of periapical health, whereas an adequate coronal restoration can partly compensate for a technically poor root filling. Evidence on the exact critical interval for restoration is limited and largely indirect, but a delay of more than a few weeks, or any loss of the temporary seal, increases the biological risk. Cuspal coverage of posterior teeth is associated with better survival. The definitive coronal restoration should be regarded as an integral final step of root canal treatment rather than a separate restorative procedure. It should be placed as soon as clinically feasible, ideally in the same visit or within a short interval, and should be technically sound. Well-designed prospective studies are still needed.

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eISSN: 2583-1194

Introduction

Root canal treatment (RCT) is a fundamental therapeutic procedure in endodontic dentistry, primarily aimed at preserving natural teeth affected by irreversible pulpitis, pulp necrosis, and apical periodontitis. The principal objectives of endodontic treatment are the elimination of microorganisms and infected tissues from the root canal system, prevention of microbial reinfection, and promotion of healing of the periapical tissues [1] . Although successful root canal treatment depends on several interconnected clinical and biological factors, the long-term outcome is not determined solely by the quality of root canal instrumentation, disinfection, and obturation. The subsequent restoration of the treated tooth represents an equally important component of comprehensive endodontic care. In particular, the timing and quality of definitive coronal restoration may substantially influence the biological and structural prognosis of endodontically treated teeth, including the likelihood of achieving complete periapical healing and maintaining long-term tooth survival [2].

Apical periodontitis is an inflammatory condition affecting the periapical tissues, usually resulting from microbial infection within the root canal system. Bacterial microorganisms and their metabolic products can penetrate the root canal system and stimulate an inflammatory response in the surrounding periodontal ligament and alveolar bone, potentially leading to periapical radiolucency, bone resorption, and destruction of periapical structures. The primary objective of root canal treatment in teeth with apical periodontitis is to reduce the microbial burden to a level compatible with tissue healing and subsequently prevent further microbial contamination [2]. However, even when technically adequate root canal treatment has been performed, persistent or recurrent microbial infection may compromise the healing process. One of the most important potential sources of such infection is leakage through the coronal aspect of the treated tooth. Therefore, achieving an effective coronal seal is essential for maintaining the biological environment established during endodontic treatment and supporting favorable periapical outcomes [3].

The coronal restoration serves several important functions beyond restoring the anatomical shape and functional integrity of the tooth. It protects the remaining dental tissues against occlusal forces, reduces the risk of fracture, restores masticatory efficiency, and, most importantly, provides a protective barrier against the penetration of microorganisms and oral fluids into the root canal system. Following root canal obturation, the root canal filling material and associated intracanal sealing components are expected to provide resistance to microbial penetration from both the apical and coronal directions [1]. Nevertheless, root canal obturation alone cannot guarantee complete protection against bacterial contamination. Defective temporary restorations, marginal discrepancies, inadequate restorative materials, and delayed placement of definitive restorations may allow microorganisms and their by-products to penetrate the root canal system. Such contamination may reactivate or maintain periapical inflammation, potentially resulting in delayed healing or persistent apical periodontitis [3].

The timing of definitive coronal restoration following root canal treatment is an important clinical consideration that may influence the success of endodontic therapy. Ideally, a definitive restoration should be placed as soon as clinically feasible after completion of root canal treatment, provided that the tooth is suitable for restoration and the required clinical conditions have been achieved. Delays in definitive restoration may expose the tooth to prolonged periods of temporary sealing, increasing the possibility of marginal deterioration, loss of restorative material, microleakage, and subsequent bacterial contamination. Temporary restorative materials are generally intended for short-term protection rather than long-term maintenance of an effective coronal seal. Their physical and mechanical properties, including resistance to wear, fracture, and dissolution, may be inferior to those of definitive restorative materials. Consequently, prolonged reliance on temporary restorations may increase the risk of coronal leakage and compromise the microbial control achieved during root canal treatment [4].

The interval between completion of root canal obturation and placement of the definitive restoration may vary considerably depending on patient-related, clinical, and healthcare-system factors. These may include financial limitations, appointment availability, the need for additional restorative procedures, the presence of persistent symptoms, and the complexity of the restorative treatment. Although certain clinical situations may justify a short delay, unnecessarily prolonged intervals should be avoided because the temporary restoration may become damaged, dislodged, or unable to maintain an adequate marginal seal. Furthermore, repeated exposure of the coronal access cavity to the oral environment may facilitate bacterial penetration into the root canal system, potentially leading to reinfection and persistence of periapical inflammation [5].

From a biological perspective, the timing of definitive restoration may influence the continuity of the protective barrier established during endodontic treatment. An early and adequately sealed restoration may minimize the opportunity for microbial ingress, thereby supporting the resolution of periapical inflammation and the regeneration of damaged periapical tissues.

Conversely, delayed restoration may increase the period during which the tooth remains vulnerable to coronal contamination. However, the relationship between restoration timing and periapical healing is potentially influenced by several confounding variables, including the initial periapical diagnosis, preoperative lesion size, quality of root canal disinfection and obturation, and the integrity of the temporary restoration. Therefore, the effect of restoration timing should be evaluated alongside other important prognostic factors rather than considered an isolated determinant of treatment success [6].

Biological Rationale

Apical Periodontitis as an Infectious Disease

Apical periodontitis is an inflammatory response of the periradicular tissues to microorganisms and their products in the root canal system. Healing after treatment depends on the reduction of the intracanal microbial load to a level compatible with host defence and on the prevention of subsequent reinfection. Histological investigation of root-filled teeth with persistent disease has shown that intraradicular biofilms are present in the majority of failed cases, and that in a number of them coronal leakage could be identified as a likely source of the infection. Reinfection through the crown therefore represents a plausible and preventable cause of post-treatment disease.

Coronal Leakage as a Route of Reinfection

The concept that the coronal seal is a critical element of endodontic success was reviewed by Saunders and Saunders, who concluded that coronal leakage can permit bacteria, endotoxins, and nutrients to reach the periapical tissues along the interface between the root filling and the canal wall [5]. Gutta-percha and sealers do not bond reliably to dentine over long periods, and the gutta-percha mass is not intrinsically bacteria-proof, which means that the root filling cannot be relied upon as the sole barrier against the oral environment.

Laboratory Evidence on the Speed of Recontamination

A series of in vitro studies has attempted to quantify how quickly an unsealed obturated canal can become recontaminated. The key studies are summarised in Table 1. Swanson and Madison showed that dye penetration along the filled canal occurred after short exposure periods and increased with time [6]. Torabinejad and colleagues demonstrated that Staphylococcus epidermidis penetrated the full length of coronally unsealed obturated roots in a mean of about 19 days, and that Proteus vulgaris required considerably longer [7]. Magura and co-workers found that human saliva could traverse the entire length of obturated canals within a relatively short period [8], and Siqueira and colleagues showed that Enterococcus faecalis penetrated canals filled with three different techniques, none of which was immune to leakage [9].

Table 1. Selected laboratory studies on coronal leakage of obturated root canals

Study	Model and challenge	Principal finding
Swanson and Madison [6]	Extracted obturated teeth exposed coronally to a dye tracer	Dye penetration occurred after short exposure and increased with time
Torabinejad et al. [7]	Obturated roots exposed to S. epidermidis and P. vulgaris	Bacteria reached the apex in a mean of about 19 days (S. epidermidis); P. vulgaris took longer
Magura et al. [8]	Obturated canals exposed to human saliva	Saliva penetrated the length of the root filling within a relatively short period
Siqueira et al. [9]	Canals obturated with three techniques challenged with E. faecalis	No obturation technique prevented bacterial leakage

These findings must be interpreted with caution. In vitro models use extracted teeth, lack host defence, do not reproduce the clinical loading cycle, and expose the canal to a continuous heavy inoculum. They nevertheless establish a clear principle: obturation alone does not provide a lasting barrier, and the interval of exposure is biologically important.

Natural Resources for Human Health
eISSN: 2583-1194

The Clinical Significance of Leakage

The clinical translation of laboratory leakage is not straightforward. Ricucci and colleagues examined root-filled teeth that had been exposed to the oral cavity through loss of the restoration or caries and observed that the periapical consequences were variable and were influenced by factors such as the quality of the root filling and the duration of exposure [10]. This suggests that coronal exposure increases risk but does not invariably lead to disease, and it supports the view that the host response, the virulence of the invading flora, and the quality of the existing seal modulate the outcome.

Timing of the Definitive Coronal Restoration

Why Timing Matters

Between completion of obturation and placement of the definitive restoration the canal system is protected only by a temporary material, which is often thin, subject to wear and fracture, and prone to marginal leakage. The longer this period lasts, the greater the cumulative probability that the seal will be breached. The laboratory evidence outlined above indicates that this breach can result in recontamination within weeks [7,8,9].

Evidence from Clinical Studies

Direct clinical evidence for an exact safe interval is sparse. Most available information comes from retrospective radiographic surveys that cannot control confounders such as patient compliance, access to care, and tooth type. Nevertheless, the studies in Table 2 consistently report that teeth lacking a technically adequate coronal restoration are more frequently associated with apical periodontitis.

Table 2. Selected clinical and epidemiological studies relating coronal restoration to periapical status

Study	Design	Principal finding
Ray and Trope [3]	Radiographic survey of 1010 root-filled teeth	Periapical health was most frequent with good root filling plus good restoration (91.4%) and least frequent with both poor (18.1%); good filling with poor restoration 44.1%; poor filling with good restoration 67.6%
Tronstad et al. [4]	Radiographic survey of root-filled teeth	Technical quality of the root filling appeared more influential than that of the coronal restoration
Hommez et al. [11]	Radiographic survey, Belgian population	Both root filling and restoration quality were associated with periapical health; teeth with both adequate had the lowest disease prevalence
Kirkevang et al. [12]	Population-based survey, Denmark	Inadequate root filling and inadequate restoration were each associated with a higher prevalence of apical periodontitis
Dugas et al. [13]	Two Canadian populations	Treatment quality, including that of the restoration, was related to periapical health
Tavares et al. [14]	Urban French population	Poor root fillings and poor coronal restorations were both associated with apical periodontitis

Interpreting the Timing Data

Several lines of reasoning converge on the recommendation that the definitive restoration should be placed promptly. First, the interval to leakage in the laboratory is measured in days to weeks [7,8], while many patients wait considerably longer than that for the permanent restoration. Second, the epidemiological associations suggest that teeth restored inadequately have poorer periapical status [3,11,12]. Third, the periapical tissues have already been compromised in most cases of retreatment and are less able to tolerate a renewed bacterial challenge. It should be stressed, however, that none of these lines of evidence establishes a precise cut-off, and that a short delay with a well-made, intact temporary restoration is not equivalent to a long delay with a failing one.

Single-Visit Versus Staged Restoration

Placing a bonded core or a definitive direct restoration in the same visit as obturation eliminates the temporary phase altogether and therefore removes the timing variable. The practical limitation is the need for adequate isolation, tooth structure, and appointment time. Where the final indirect restoration cannot be provided at once, a well-adapted bonded intermediate restoration with adequate thickness is preferable to a thin temporary dressing, and the patient should be informed that delay carries a biological risk.

Quality of the Definitive Coronal Restoration

Defining Quality

In most epidemiological studies, the quality of a coronal restoration is judged radiographically by the presence of overhangs, open margins, secondary caries, and the adaptation of the margin to the tooth, with additional clinical criteria in some studies. Radiographic assessment is a surrogate of the actual seal and has well-known limitations, because it cannot detect leakage at buccal or lingual margins or small gaps. The criteria most often used are summarised in Table 3.

Table 3. Criteria commonly used to judge the technical quality of a coronal restoration

Parameter	Adequate	Inadequate
Marginal adaptation	Continuous, no visible gap or step	Open margin, overhang, or ditching
Caries	None adjacent to restoration	Recurrent caries or radiolucency at margin
Contour and contact	Anatomical, with proper proximal contact	Over- or under-contoured, open contact
Material integrity	Intact, no fracture or loss	Fractured, worn, or missing material
Extent of coverage	Covers the pulp chamber floor and canal orifices	Chamber floor or orifices exposed

Restoration Quality Versus Root Filling Quality

The relative contribution of the two factors has been studied extensively. Ray and Trope found that the combination of a good root filling and a good restoration produced the highest rate of periapical health, and that when only one of the two was adequate, the adequate restoration was slightly more strongly associated with health than the adequate root filling [3]. Other surveys have found the root filling to be the more influential factor [4], and Hommez and colleagues and Kirkevang and colleagues reported that both mattered [11,12]. A systematic review and meta-analysis by Gillen and co-workers concluded that the odds of periapical health were significantly higher for both good restorations and good root fillings, and that the two factors were of broadly comparable importance, although the number of eligible studies was small and heterogeneity was considerable [15].

Taken together, these data support a combined view. The root filling and the coronal restoration act in series as barriers against reinfection. An excellent restoration can partly compensate for an imperfect root filling by limiting recontamination, and an excellent root filling cannot be expected to remain disease-free if the coronal seal is lost.

Multifactorial Outcome

The prospective study of Ng and colleagues, which followed a large cohort of treated teeth, confirmed that periapical healing depends on a combination of preoperative, intraoperative, and postoperative variables rather than on any single one [16]. Coronal restoration quality should therefore be seen as one important, modifiable factor among several, and not as a substitute for meticulous canal disinfection.

Healing Kinetics and Assessment of Outcome

Time Course of Periapical Healing

The interpretation of any study on coronal restoration depends on the time at which periapical status is assessed. Ørstavik analysed the time course of healing of chronic apical periodontitis and showed that many lesions that eventually heal do so

within the first year, although a fraction require considerably longer [17]. Sjögren and colleagues, in a long-term follow-up of several hundred treated teeth, reported success rates of about 96% for teeth with vital pulps, 86% for necrotic teeth without lesions, and 62% for teeth with preoperative apical periodontitis, and recommended a minimum observation period of four years before a final judgement is made [18]. Studies with short follow-up may therefore underestimate the later effect of a failing coronal seal, because reinfection of a previously healed tooth can produce a lesion only after months or years.

Histological Perspective

Histological investigation provides insight that radiographs cannot. Ricucci and colleagues examined root-filled teeth with apical periodontitis and found that intraradicular infection, typically organised as biofilm, was present in most specimens, and that coronal leakage could be identified as a probable source of infection in a number of cases [19]. This supports the biological plausibility of the epidemiological associations described earlier, because it links the loss of coronal seal to the presence of microorganisms in the canal system of diseased teeth.

Methodological Issues in Outcome Assessment

Periapical radiographs underestimate lesion prevalence and are subject to interobserver variation, while the criteria used for the coronal restoration are subjective. Outcome definitions also differ (strict healing versus functional retention), which partly explains why pooled success rates vary between systematic reviews [1,2].

Restoration Type, Cuspal Coverage, and Tooth Survival

Periapical healing is not the only outcome that matters, since a tooth with healed periapical tissues can still be lost through fracture or caries. Aquilino and Caplan reported that endodontically treated teeth that received a crown had significantly better survival than teeth that did not, and the benefit was clearest for posterior teeth [20]. Heling and colleagues reviewed endodontic failures caused by inadequate restorative procedures and concluded that a leaking or fractured restoration, an inadequate post space preparation, and delayed restoration can each compromise the result of otherwise well-executed treatment [21]. In a very large insurance-based population of more than 1.4 million treated teeth, Salehrabi and Rotstein reported that about 97% of the teeth remained in function after eight years, and that tooth type and the presence of definitive coronal restoration were among the factors associated with survival [22].

Taken together, these findings suggest that the choice between a direct restoration and cuspal coverage should be guided by the amount of remaining tooth structure and occlusal load, but that, regardless of the material, the restoration should seal the chamber and canal orifices effectively.

Integrating Timing and Quality: Practical Recommendations

The evidence reviewed above does not allow exact time limits to be set, but it supports a risk-based approach. Table 4 summarises a practical framework consistent with the available laboratory and clinical data [3,7,8,11,12,19,21].

Table 4. Practical framework for timing and quality of the coronal restoration

Clinical situation	Biological concern	Suggested approach
Sufficient tooth structure and good isolation	Temporary phase can be avoided altogether	Place a bonded core or definitive direct restoration at the obturation visit
Indirect restoration planned	Interval to final restoration may exceed laboratory leakage times	Place a thick, well-adapted bonded intermediate restoration and schedule the final restoration within a few weeks
Temporary restoration lost, fractured, or leaking	Exposure of the filling to saliva and bacteria	Treat as an emergency; clean and re-seal, and consider re-disinfection if exposure has been prolonged
Poor root filling, good restoration available	Restoration may partly limit reinfection	Evaluate for retreatment according to the periapical status; do not replace a sound restoration without need

Clinical situation	Biological concern	Suggested approach
Good root filling, defective restoration	Coronal route of reinfection is open	Replace the restoration promptly and monitor radiographically
Posterior tooth with extensive loss of structure	Fracture risk and marginal failure	Provide cuspal coverage with a well-fitting restoration

Limitations of the Current Evidence

Several limitations restrict the strength of the conclusions that can be drawn. Most clinical data are cross-sectional or retrospective, so causality cannot be established and temporal sequence is uncertain. Confounding by patient factors, operator skill, and the quality of canal disinfection is likely, and the quality of both the root filling and the restoration is judged radiographically, which is an imperfect surrogate of the actual seal. Laboratory leakage models overestimate clinical exposure in some respects and underestimate it in others. Few studies have recorded the exact interval between obturation and definitive restoration, which is why the optimal timing remains uncertain. The overall position is summarised in Table 5.

Table 5. Summary of the evidence on the main clinical questions

Clinical question	Main sources	Strength and direction of evidence
Can an unsealed obturated canal be recontaminated?	Laboratory studies [7,8,9]	Consistent, but in vitro; recontamination within days to weeks
Is restoration quality associated with periapical health?	Surveys and meta-analysis [3,11,12,15]	Consistent association; observational
Is restoration quality as important as root filling quality?	Surveys and meta-analysis [3,4,15]	Conflicting in individual studies; broadly comparable in the pooled estimate
What is the maximum safe delay before the definitive restoration?	Indirect evidence only [7,8,21]	Insufficient direct evidence; earlier is safer
Does crown placement improve tooth survival?	Cohort data [20,22]	Favourable, especially for posterior teeth

Future Research Directions

Prospective cohort studies and, where ethically feasible, randomised trials are needed in which the interval to definitive restoration is recorded and compared, together with standardised assessment of the restoration by clinical examination and not only by radiographs. Cone-beam computed tomography may improve the detection of periapical lesions in such studies, although its use must be justified by the clinical question. Research on the interaction between restoration timing and the quality of canal disinfection, on adhesive materials that improve the seal at the canal orifices, and on patient-level factors such as compliance and caries risk would further refine clinical guidance.

Conclusion

The definitive coronal restoration should be regarded as an integral part of root canal treatment. Laboratory evidence shows that obturated canals can be recontaminated rapidly when the coronal seal is lost, and clinical studies show that teeth with adequate root fillings and adequate restorations have the best periapical status, whereas an adequate restoration can partly compensate for a deficient root filling. Although the exact safe interval cannot be defined from current data, the evidence supports placing the definitive restoration at the same visit when possible, or as soon as feasible afterwards, with a high technical standard, and monitoring the tooth over a sufficient follow-up period.

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