

The One-Visit Debate in Endodontics: A Narrative Review of Microbiological Evidence, Postoperative Pain and Long-Term Periapical Healing Outcomes

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Abstract

Root canal treatment aims to eliminate intracanal microorganisms, prevent reinfection and preserve the natural dentition, with the optimal number of treatment visits remaining a subject of ongoing clinical debate given the microbiological complexity of root canal infections and patient-specific anatomical variability. A narrative review was conducted using PubMed, Google Scholar and the Cochrane Database of Systematic Reviews, prioritizing systematic reviews, randomized clinical trials and prospective clinical studies, with *in-vitro* and narrative studies included as supportive evidence, to critically evaluate current evidence comparing single-visit and multiple-visit root canal treatment regarding microbiological outcomes, postoperative pain, flare-up incidence and long-term periapical healing. No clinically significant differences were identified between protocols when modern chemo-mechanical techniques are applied; postoperative pain profiles are broadly similar, though single-visit retreatment showed greater pain intensity at 48 hours and flare-up incidence and periapical healing outcomes were primarily influenced by biological, anatomical and case-specific factors rather than visit number. No universally superior protocol exists and clinical decisions should be guided by pulpal status, periapical pathology, canal complexity and presence of active infection.

Keywords: Root Canal Therapy; Single-Visit Endodontics; Multi-Visit Root Canal Treatment; Periapical Healing; Postoperative Pain; Flare-Up; Microbiology; Calcium Hydroxide; Chemo-Mechanical Debridement; Instrumentation

Introduction

Over the past several decades, root canal treatment has undergone substantial transformation, driven by advances in instrumentation, irrigant delivery systems and three-dimensional imaging. Despite these developments, one of the most persistent and clinically relevant debates in endodontics remains unresolved: whether root canal treatment should be completed in a single visit or across multiple appointments [1]. The answer is not straightforward, as it requires careful consideration of microbiological evidence, postoperative pain profiles and long-term periapical healing outcomes [2].

Historically, multi-visit root canal therapy was the standard of care, primarily because the limitations of early techniques; including inadequate disinfection protocols and the absence of reliable apex locators, made completing treatment in one session unpredictable and potentially unsafe. The concept of single-visit endodontics emerged later as an attempt to reduce patient burden, minimize the risk of interappointment contamination through temporary seal failure and improve overall treatment efficiency [2,3]. Today, with patients increasingly prioritizing convenience and reduced chair time, the appeal of single-visit treatment has grown considerably. However, clinical decision-making cannot be driven by patient preference alone.

The complexity of root canal anatomy, including lateral canals, isthmuses, apical deltas and dentinal tubule ramifications; continues to make complete bacterial elimination a significant challenge, regardless of the number of visits [4]. Modern endodontic protocols address this through advances in three-dimensional cleaning and obturation techniques, rotary nickel-titanium instrumentation and enhanced irrigant delivery [5]. Cone-Beam Computed Tomography (CBCT) has further improved diagnostic accuracy and pre-treatment planning, while ultrasonic and sonic irrigant activation systems have measurably increased disinfection efficacy within anatomically complex canals [6,7].

Long-term treatment success is fundamentally linked to effective microbial control and its ability to promote periapical healing. When bacterial load is not adequately reduced, persistent infection sustains periapical inflammation and undermines healing [8]. Postoperative pain, which occurs in a clinically significant proportion of cases regardless of treatment protocol, represents another important outcome measure, as it affects patient satisfaction and compliance [9]. The introduction of bioceramic-based sealers has added a new dimension to this discussion, given their superior biocompatibility and ability to promote periapical tissue repair when compared to traditional alternatives [10].

Ultimately, the decision between single-visit and multi-visit root canal therapy cannot be reduced to a one-size-fits-all recommendation. It must be individualized based on the preoperative status of the tooth, pulp vitality, the presence and extent of periapical pathology, canal complexity and the clinician's access to contemporary technology [11]. The purpose of this review is to critically evaluate the current evidence comparing both treatment approaches with respect to microbial outcomes, postoperative pain and long-term periapical healing, with the aim of providing a framework for evidence-based clinical decision-making.

The Microbiology of Root Canal Infection: Understanding What We Are Treating

The identification of root canal microbiota is fundamental to understanding endodontic disease, given that the vast majority of pulpal and peri-radicular pathologies are microbial in origin. From a clinical standpoint, endodontic infections represent one of the most microbiologically complex scenarios encountered in dental practice, owing to the polymicrobial nature of root canal infections and the anatomical challenges that hinder complete disinfection [12]. This process is initiated when the root canal system becomes exposed to the oral environment; through dental caries, traumatic injuries, crown or root fractures or periodontal communication, allowing microorganisms to invade the pulp space, triggering inflammation and, ultimately, pulpal necrosis [13,15].

The loss of pulpal vitality produces an environment highly conducive to bacterial colonization and proliferation. Reduced vascular perfusion and progressive tissue breakdown compromise local defense mechanisms, permitting the establishment and expansion of diverse microbial communities [13]. These shifts in the intraradicular environment give rise to distinct microbial profiles, whose specific composition is largely determined by the type and chronicity of the infection [15].

Endodontic infections are broadly classified as primary, secondary or persistent. Primary infections occur when microorganisms penetrate a previously uninstrumented root canal system, typically as a consequence of carious exposure, dental trauma or other conditions that disrupt tooth integrity [12]. These infections are characteristically polymicrobial and are dominated by obligate anaerobic bacteria, particularly Gram-negative rods such as *Fusobacterium nucleatum*, *Prevotella intermedia* and *Peptostreptococcus spp.*, although facultative Gram-positive species including *Actinomyces*, *Streptococcus* and *Cutibacterium* (formerly *Propionibacterium*) are also frequently detected [16,17].

Secondary infections arise when microorganisms gain access to a previously treated root canal system, generally as a result of defective coronal restorations, inadequate temporary sealing between appointments or intraoperative contamination during

treatment [18]. Persistent infections, in contrast, involve the survival of microorganisms that resisted the chemomechanical debridement and antimicrobial strategies employed during initial treatment, originating from either primary or secondary infection [15].

Both secondary and persistent infections tend to harbor less diverse and more ecologically selective microbial communities compared to primary infections, with a predominance of facultative anaerobic Gram-positive bacteria [19]. Among these, *Enterococcus faecalis* is consistently identified as one of the most prevalent species in previously treated canals and is strongly associated with endodontic failure, owing to its exceptional ability to tolerate adverse intracanal conditions such as nutrient deprivation, elevated pH and anaerobiosis [20,21].

The persistence of *E. faecalis* and related organisms is intimately tied to their capacity for biofilm formation, a structured mode of growth in which bacteria aggregate within a self-produced extracellular polymeric matrix. This matrix confers protection against environmental stress, facilitates nutrient acquisition and functions as a diffusion barrier that significantly reduces the penetration and efficacy of antimicrobial irrigants [22,23]. Biofilm distribution within the root canal system is spatially variable and its removal remains challenging. While biofilm most commonly adheres to the main canal walls, it can extend into anatomically inaccessible structures such as dentinal tubules, lateral canals, apical ramifications, isthmuses and recesses, territories that instruments and irrigants frequently fail to reach [24].

The presence of these microbial communities triggers a host immune response driven by bacterial byproducts, including Lipopolysaccharides (LPS), proteolytic enzymes and cytotoxic metabolites. This response promotes the release of pro-inflammatory mediators, recruitment of inflammatory cells and suppuration during the acute phase. When the microbial irritation persists, the lesion transitions into a chronic phase characterized by ongoing alveolar bone resorption and the formation of granulomatous tissue or periapical cyst-like structures, representing an immunological attempt to contain the advancing infection [25-27]. Understanding this microbiological complexity is directly relevant to the single-visit versus multi-visit debate, as the adequacy of bacterial elimination within a single appointment; particularly in the presence of established biofilms and anatomically complex canals, remains one of the most contested questions in contemporary endodontics.

Instrumentation, Irrigation and Interappointment Medicament: The Microbiological Evidence for Visit Number

The success of endodontic treatment is fundamentally dependent on reducing the microbial load within the root canal system to levels compatible with periapical healing. Biomechanical instrumentation, combined with chemical irrigants, activation techniques and intracanal medicaments, plays a central role in disrupting biofilm architecture, eliminating residual bacteria and creating conditions that support tissue repair [1,2]. However, the question of how many clinical visits are required to achieve optimal disinfection and whether additional appointments confer a meaningful microbiological benefit, remains one of the most debated issues in contemporary endodontics. The available evidence suggests that two-visit treatment incorporating calcium hydroxide may offer some antimicrobial advantage in selected clinical scenarios, but this benefit is neither consistent nor robust enough to establish multi-visit therapy as routinely superior to well-executed single-visit chemomechanical preparation [28].

When multi-visit treatment is indicated, the rationale for interappointment medication is to suppress microorganisms that survive mechanical instrumentation alone. Calcium hydroxide [$\text{Ca}(\text{OH})_2$], the most widely used intracanal medicament, exerts its antibacterial effect primarily through its high alkalinity, inducing protein denaturation and disruption of bacterial cell membranes [29]. Single-visit treatment, in contrast, offers clear advantages in terms of patient convenience, reduced risk of interappointment coronal leakage through temporary seal failure and fewer overall appointments [1]. The central clinical question, then, is whether the incremental antimicrobial effect of $\text{Ca}(\text{OH})_2$ as a dressing is large, reproducible and clinically meaningful enough to justify a second appointment in routine cases.

The strongest and most consistent finding in the current literature is that mechanical shaping combined with chemical irrigation remains the primary engine of root canal disinfection. A comprehensive review of irrigants and activation systems published in 2023 concluded that adequate chemomechanical preparation and irrigant delivery are the principal determinants of intracanal bacterial reduction [28]. This makes the selection of irrigant solution and delivery technique a clinically critical decision, particularly in the context of single-visit therapy where no interappointment period exists to supplement disinfection.

Sodium hypochlorite (NaOCl), used alongside chelating agents such as EDTA, constitutes the current standard irrigant protocol and has demonstrated broad-spectrum antimicrobial efficacy against root canal pathogens, including *Enterococcus faecalis* [30,31]. Advanced irrigant activation systems; including Passive Ultrasonic Irrigation (PUI), Photon-Induced Photoacoustic Streaming (PIPS) and negative apical pressure techniques, have been shown to significantly enhance irrigant penetration and bacterial reduction beyond conventional syringe delivery [30]. *In-vitro* evidence demonstrates that PIPS combined with NaOCl achieves superior bacterial elimination compared to conventional needle irrigation, supporting its use in single-visit protocols where maximizing disinfection efficiency within a single appointment is essential.

Comparative studies evaluating bacterial reduction between single-visit and multi-visit root canal treatment have not demonstrated statistically significant differences in treatment success when modern chemomechanical protocols are applied [31]. This finding challenges the longstanding assumption that additional appointments inherently improve microbiological outcomes and shifts the focus toward the quality of disinfection achieved within each session rather than the number of sessions performed.

A critical limitation of $\text{Ca}(\text{OH})_2$ is its inability to reliably eliminate *E. faecalis* from within biofilms. This organism tolerates environmental pH levels of up to 11 and within a biofilm matrix, it demonstrates additional resistance to the high alkalinity produced by $\text{Ca}(\text{OH})_2$ which reaches a pH of approximately 12.5 in solution, owing to reduced medicament diffusion through the extracellular polymeric matrix [32]. This resistance limits the reliability of $\text{Ca}(\text{OH})_2$ as a predictable anti-biofilm agent, even when placed for extended periods. Nevertheless, $\text{Ca}(\text{OH})_2$ has shown consistent value in reducing postoperative symptoms and managing acute presentations. Evidence supports its use as an interappointment medicament in symptomatic cases, retreatments and teeth presenting with active suppuration or large periapical lesions [29,31].

The influence of anatomical complexity on visit number is also an important consideration. A prospective clinical study by Kaya Mumcu, et al., demonstrated that endodontic case difficulty, classified according to the American Association of Endodontists (AAE) assessment form; was significantly correlated with both the incidence of procedural mishaps and the number of treatment visits required [32]. Cases categorized as high difficulty were more likely to involve procedural complications such as instrument separation, apical transportation or perforation, each of which independently necessitates additional appointments. This finding reinforces that the decision between single-visit and multi-visit treatment cannot be made in isolation from a thorough case difficulty assessment [32].

Taken together, the evidence supports chemomechanical preparation and irrigation as the primary determinants of bacterial load reduction in root canal treatment. Calcium hydroxide as an interappointment dressing may offer meaningful benefit in symptomatic, necrotic or anatomically complex cases; however, current evidence does not support its routine use as a justification for defaulting to multi-visit treatment in all cases.

Postoperative Pain and Flare-Up Rates: What the Evidence Actually Shows

Postoperative pain is one of the most clinically relevant outcomes reported by patients undergoing endodontic treatment. It reflects the biological response of the periapical tissues following instrumentation and obturation and, unlike microbiological or radiographic endpoints, represents an immediate measure that directly shapes the patient's perception of treatment success [33]. In the context of the single-visit versus multi-visit debate, postoperative pain provides a practical and patient-centered lens through which to evaluate the short-term consequences of each clinical protocol [34].

Systematic review evidence indicates that postoperative pain occurs with broadly similar frequency and intensity across both treatment approaches. The majority of patients report mild to moderate discomfort within the first 24-48 hours following treatment, with progressive resolution thereafter. Pooled analyses suggest no statistically significant differences between single-visit and multi-visit protocols in overall postoperative pain incidence, although a subset of studies has reported slightly lower pain scores in the single-visit group during the immediate postoperative period [33,35]. Additional evidence from comprehensive overviews of pain management following endodontic treatment corroborates these findings, indicating that any observed differences between protocols are minimal and clinically negligible when standardized operative techniques are applied [8].

The biological mechanisms underlying postoperative endodontic pain are primarily driven by acute inflammatory activation of periapical tissues. Mechanical instrumentation of the root canal system can result in apical extrusion of debris and irrigants, triggering a local inflammatory cascade mediated by prostaglandins, cytokines and neuropeptides, culminating in nociceptive pathway activation and the sensation of pain [8,36]. Critically, this inflammatory response is not unique to either treatment approach; it may occur regardless of whether treatment is completed in one or multiple visits, as it is more closely related to the extent of periapical irritation and host susceptibility than to the scheduling of clinical appointments [37].

Cochrane-level comparative analyses reinforce that the number of treatment visits does not significantly influence either the incidence or the severity of postoperative pain in permanent teeth [1]. These findings warrant careful interpretation, however, given the considerable clinical heterogeneity across included studies; differences in pulpal status, canal morphology, irrigant protocols and operator experience may all contribute to variability in individual pain outcomes that pooled statistics cannot fully capture [38].

Flare-ups, defined as acute exacerbations of endodontic origin characterized by spontaneous pain and/or swelling requiring unscheduled clinical intervention, represent a relatively infrequent yet clinically significant complication of root canal treatment [1,34,37]. Current evidence does not demonstrate a consistent difference in flare-up incidence between single-visit and multi-visit approaches. Rather, their occurrence appears to be more strongly associated with the preoperative infectious status of the tooth and the individual host immune response than with the number of clinical appointments [1,34].

Evidence from randomized clinical trial data in the retreatment context provides additional insight. A recent trial comparing single-visit and two-visit endodontic retreatment found that postoperative pain was broadly comparable between groups at most follow-up intervals; however, single-visit retreatment was associated with significantly greater pain intensity at 48 hours following obturation compared to two-visit treatment [35]. This nuance is clinically important, while overall pain trajectories may be similar, specific time-point differences in retreatment scenarios may be relevant for patient counseling and postoperative analgesic planning.

Individual patient-related factors contribute substantially to the variability in postoperative pain reports across both protocols. Psychological factors, including dental anxiety, pain catastrophizing and baseline pain thresholds, significantly influence subjective pain intensity independent of the treatment approach used [8,35]. Preoperative pulpal and periapical status is equally determinative: teeth presenting with pulpal necrosis and symptomatic apical periodontitis consistently demonstrate higher postoperative pain levels compared to vital cases, regardless of whether treatment is performed in one or multiple visits.

Long-Term Periapical Healing and Treatment Success: Does the Number of Visits Matter?

The primary objective of root canal treatment is to eliminate intracanal infection, resolve periapical inflammation and preserve long-term tooth function and retention [36]. Whether this goal is achieved equivalently through single-visit or multi-visit protocols has been the subject of sustained clinical investigation. Despite the considerable variability in study design, follow-up periods and outcome criteria across the existing literature, the current evidence consistently indicates that single-visit and multi-visit root canal treatment do not produce clinically meaningful differences in long-term periapical healing or overall treatment success, provided that contemporary chemomechanical protocols are properly executed [37,38].

Technological advances have profoundly reshaped how endodontic outcomes are assessed and predicted. Cone-Beam Computed Tomography (CBCT) in particular has transformed diagnostic capability, providing three-dimensional visualization of root canal microanatomy, periapical pathology extent and complex anatomical configurations that two-dimensional periapical radiography consistently underestimates [39]. This enhanced imaging capacity is not merely diagnostic, it directly influences treatment planning decisions, including the appropriateness of single-visit versus multi-visit protocols, by enabling more precise assessment of case difficulty, canal complexity and preoperative periapical status. The integration of CBCT-assessed prognostic factors into outcome analysis has further refined our understanding of which variables most reliably predict treatment success [39,40].

Periapical healing is the primary radiographic and clinical criterion by which endodontic treatment success is evaluated. The healing process is inherently time-dependent and may extend over six to twelve months following treatment, with

comprehensive outcome assessment ideally conducted over a monitoring period of two to four years depending on preoperative pathology [41]. Regarding retreatment-specific outcomes, a randomized clinical trial with 24 months of follow-up found no statistically significant difference in success rates between single-visit and two-visit root canal retreatment; reinforcing the broader pattern that treatment scheduling does not independently determine periapical healing outcomes [42,43].

An important yet frequently underappreciated variable in this debate is the role of surgical endodontic retreatment; specifically Endodontic Microsurgery (EMS), as a case-specific pathway when non-surgical treatment fails to achieve periapical resolution. A retrospective cohort study by Lai, et al., demonstrated that EMS outcomes are significantly influenced by preoperative lesion size and tooth type, underscoring that periapical healing is inherently multifactorial and time-dependent rather than determined solely by the initial treatment protocol [42,44]. Similarly, root canal configuration has been identified as an independent determinant of treatment success: an international expert consensus established that increasing case difficulty; driven by anatomical complexity, canal curvature and calcification, is associated with lower success rates, regardless of the number of visits [45,46].

In summary, the available evidence does not support a protocol-driven, one-size-fits-all approach to the single-visit versus multi-visit decision. Rather, it points toward meaningful biological and anatomical differences across case types that should guide individualized clinical planning [47,48]. Vital pulp cases, necrotic cases and retreatment cases each present distinct microbiological and healing conditions that may influence how effectively disinfection is achieved and how reliably periapical healing occurs [49]. Accordingly, the number of treatment visits should be determined by case-specific factors, including pulpal status, periapical pathology, canal complexity and prognostic indicators of long-term healing, rather than by institutional habit or operator preference. Long-term data over observation periods spanning up to 37 years confirm that endodontically treated teeth can maintain high survival and success rates when appropriate case selection, treatment execution and restorative management are combined [36,50].

Conclusion

The decision between single-visit and multi-visit root canal treatment cannot be reduced to a simple protocol preference. It is a clinical judgment that must integrate microbiological, anatomical, symptomatic and patient-specific variables simultaneously. Based on the current evidence, general guidance can be offered: single-visit root canal treatment is appropriate for cases presenting with vital pulp tissue, uncomplicated canal anatomy, absence of periapical radiolucency and no active exudate or acute infection. Multi-visit treatment, by contrast, remains the preferred approach when active infection, purulent exudate, periapical pathology or anatomically complex root canal systems are present; scenarios in which interappointment intracanal medicament placement with calcium hydroxide may provide additional clinical benefit.

With respect to periapical healing, the existing evidence does not identify a statistically significant difference between single-visit and multi-visit outcomes when modern chemomechanical protocols are applied under appropriate case selection.⁴⁴ The biological rationale for multi-visit treatment; enhanced bacterial reduction through interappointment calcium hydroxide dressing, does carry some mechanistic support. Systematic review and meta-analysis evidence from animal studies demonstrates that two-visit endodontic treatment with calcium hydroxide-based intracanal medication yields superior histopathological periapical outcomes compared to single-visit treatment. Furthermore, multi-session disinfection protocols have shown a meaningful advantage in endotoxin reduction from infected root canals, particularly when calcium hydroxide is maintained for 14 to 30 days. This biological benefit, however, is significantly attenuated when the dressing period is limited to seven days, at which point the advantage over single-visit chemomechanical preparation becomes statistically inconsistent.

With respect to postoperative pain, the majority of evidence does not support a clinically significant difference between protocols overall. However, nuances exist: some studies report higher pain intensity at specific early time points; notably at 6 hours and 48 hours, following single-visit treatment, particularly in the retreatment context. This does not negate the appropriateness of single-visit treatment in selected cases, but it does suggest that postoperative analgesic protocols and patient counseling should be tailored accordingly.

The clinical implication is clear: neither single-visit nor multi-visit root canal treatment is universally superior. Each protocol has a defined role within a case-stratified framework that considers pulpal status, periapical condition, canal morphology, the

presence of active infection and available technology. The appropriate number of visits is a clinical decision, not a protocol-driven default and should be determined on a case-by-case basis with the patient's biological and anatomical reality as the primary guide.

Future research should prioritize well-designed, adequately powered randomized controlled trials with long-term follow-up periods; preferably four years or beyond, stratified by pulpal diagnosis, periapical status and canal complexity. Standardization of outcome criteria, particularly with respect to CBCT-based periapical assessment, is essential to improve the comparability of future studies and to generate the high-quality evidence needed to support truly individualized clinical decision-making in endodontics.

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Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore was exempt.

Informed Consent Statement

Not Applicable.

Authors' Contributions

All authors contributed equally to this paper.

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