ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 8, Issue – 6, November – 2025, Page No. : 122 - 130

Types of Endodontic Failures and Retreatment Strategies - A Narrative Review of Literature

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Citation of this Article: Dr Dharmi Dobariya, Dr Naval Ghule, Dr Sindhu Chavva, Aleesha Kalam, Dr Padmaja Madhumala Yejju, “Types of Endodontic Failures and Retreatment Strategies - A Narrative Review of Literature”, IJDSIR- November – 2025, Volume – 8, Issue – 6, P. No. 122 – 130.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

Despite significant advancements in endodontic techniques, root canal therapy may sometimes fail, even when performed according to the highest clinical protocols. The predominant cause of endodontic failure is often persistent or secondary intraradicular infection, though certain cases may arise from nonmicrobial factors, whether intrinsic or extrinsic in nature.

As the prevalence of previously treated teeth increases, endodontic retreatment has become an essential aspect of contemporary practice. It provides patients with a viable alternative to extraction, restoring the health and function of a compromised tooth. The primary aim of nonsurgical retreatment is to re-enter the root canal system, remove previous filling materials, and ensure effective cleaning, disinfection, and re-obturation to eliminate residual infection and promote periapical healing.

Continuous progress in instrument design, magnification systems, and biocompatible materials has substantially improved the prognosis of retreatment procedures. These innovations support the preservation of natural dentition, minimising the dependence on complex and expensive prosthetic or implant-based restorations. When nonsurgical management is not feasible due to calcification, canal blockage, or complex anatomy, a surgical approach may be indicated to achieve complete debridement and sealing.

Recent developments in techniques, materials, and technology have transformed endodontic retreatment from a challenging and unpredictable process into one with highly favourable success rates. This narrative

review seeks to deliver a comprehensive and critical overview of the various types of endodontic failures and the current retreatment strategies, highlighting recent innovations that contribute to improved clinical outcomes.

Keywords: Coronal Leakage, Chlorhexidine, Obturation, Palpation, Vertical Root Fractures

Introduction

Persistent intraradicular infection most often develops when initial endodontic treatment fails to meet accepted technical standards, such as missed canals or inadequate cleaning, shaping, and obturation of the root canal system[1]. The introduction of the operating microscope has greatly enhanced visualization and magnification of complex internal anatomy, improving outcomes in previously untreated or failed cases caused by insufficient obturation, coronal leakage, undetected fractures, ledges, perforations, or fractured instruments—all of which can contribute to persistent infection[2].

Accurate technique is essential during removal of obturation materials such as gutta-percha cones and root canal sealers or pastes[3,4]. Retreatment procedures focus on re-establishing working length, ensuring complete removal of existing fillings, followed by meticulous cleaning and re-obturation. Techniques for gutta-percha removal include rotary and hand instruments, solvents, or their combinations, depending on clinical requirements[5].

When periapical pathology persists, clinicians may choose nonsurgical retreatment or surgical procedures such as apicoectomy with retrograde filling when orthograde access is not possible. 3 Incomplete canal debridement and obturation are major contributors to failure, particularly in cases managed without adequate training[6,7]. Success in retreatment depends on complete material removal and thorough disinfection using specialized NiTi rotary systems, hand files, or solvents[4].

Among microorganisms associated with post-treatment disease, Enterococcus faecalis remains a key pathogen. Current approaches target its eradication through advanced mechanical instrumentation and potent irrigants like sodium hypochlorite and chlorhexidine[8].

Continual progress in instrumentation, imaging, irrigant activation, and biomaterials has greatly enhanced the effectiveness and predictability of retreatment, reinforcing it as a biologically sound and conservative alternative to extraction and prosthetic replacement[9].

This article provides qualitative, descriptive review of literature of types of endodontic failures and retreatment strategies.

Methodology

A systematic literature search was conducted, utilizing electronic databases including PubMed and Google scholar without restriction on publication year. The search criteria consisted of terms such as ("endodontic failure" OR "endodontic disease") AND ("retreatment") AND ("strategies" OR "techniques"). Following elimination of duplicates, 31 articles remained. Additional sources were identified by scrutinizing the reference lists of articles selected for full text examination.

Endodontic failure

Endodontic failure has been defined in some studies as a recurrence of clinical symptoms along with the presence of a periapical radiolucency[10,11].

Endodontic failure is commonly characterized by the recurrence of clinical symptoms—such as persistent pain, swelling, or discharge—and the presence of a periapical radiolucency on radiographs following root canal therapy. When such failures are identified, it is essential to assess the case in order to choose an appropriate course of action, typically between non-surgical retreatment or extraction[12]. Effective diagnosis relies on both clinical examination of symptoms and radiographic assessment to identify complications, ensuring an informed and successful intervention.

Retreatment is generally initiated when the initial therapy is deemed inadequate, with the main goal of eliminating microbes that may have survived the first intervention or re-entered the canal system afterward[13].

Criteria for failure[14]

A. Clinical failure

a) Persistent subjective symptoms
b) Recurrent sinus tract or swelling
c) Predictable discomfort to percussion or palpation
d) Evidence of irreparable tooth fracture
e) Excessive mobility or progressive periodontal breakdown
f) Inability to function of the tooth

B. Radiographic failure

a) Increased width of periodontal ligament space (>2mm)
b) Lack of osseous repair within a periradicular rarefaction or increase in the size of rarefaction
c) Lack of new lamina dura formation or significant increase in osseous density in the periradicular tissues
d) The presence of osseous rarefactions in periradicular areas where previously none existed
e) Visible, patent canal space that is unfilled or represents significant voids in the obturation of the canal
f) Excessive overextension of the filling material with obvious voids in the apical third of the canal
g) Active resorption coupled with other radiographic signs of failure

C. Histologic failure

a) Presence of a moderate to severe inflammatory infiltrate
b) Lack of osseous repair with concomitant resorption of surrounding bone
c) Active resorption of cementum with no evidence of repair
d) Presence of zones of necrotic or foreign tissue remnants
e) Presence of granulation tissue and possible epithelial proliferation

Types of endodontic failure[1]

Endodontic failure occurs due to different etiological factors,

1. Persistent Intraradicular Infection

Failure caused by the continued presence of bacteria or other microorganisms inside the root canal system, often due to incomplete debridement or missed canals, leading to persistent periapical lesions and symptoms[15,16].

2. Extraradicular Infection

An infection that persists outside the root canal, such as biofilm formation on the external root surface, is unresponsive to conventional root canal treatment[17].

3. Untreated or Missed Canals

Incomplete identification, cleaning, or filling of all root canals, commonly seen in teeth with complex anatomy, results in persistent infection and failure[18,19].

4. Inadequate Debridement

Failure to thoroughly clean and remove necrotic tissue, bacteria, and debris from the root canal system allows infection to persist[14].

5. Inadequate obturation

Improper or incomplete sealing of the root canal space, leaving voids or pathways for bacterial recontamination[14,20].

6. Overextended obturation

Root canal filling material that is either extruded beyond the apex (overextension) or does not reach the apex (under extension), leading to irritation or persistence of infection[21]

7. Improper coronal seal

Failure of the coronal restoration to seal the tooth, allowing bacteria to re-enter the canal system and cause reinfection[20,22]

8. Iatrogenic errors

Procedural errors such as ledge formation, root perforation, instrument separation, and canal blockage, all of which can compromise cleaning, shaping, or sealing of the root canal[23].

9. Vertical Root Fractures

Cracking or splitting of the root structure itself, which allows bacterial ingress and makes the prognosis poor for long-term retention of the tooth

Retreatment

Retreatment focuses on reestablishing access to the apical portion of previously treated root canals, a process that differentiates it from managing untreated endodontic disease[25]. The primary goal is the complete removal of existing canal materials through a systematic coronal disassembly approach, followed by reshaping, thorough disinfection, and obturation to facilitate periapical healing[26]. Advanced techniques and technologies have significantly improved clinical outcomes. Preoperative cone-beam computed tomography (CBCT) provides superior diagnostic accuracy compared with conventional radiographs, directly influencing retreatment planning[27]. Retreatment often requires re-instrumentation of canals obstructed by previous filling materials or fractured instruments, which are generally classified as pastes and cements (20.6%), semisolid materials like gutta-percha (53.6%), and solid materials such as silver points and separated instruments (21.7%)[28,29]. Retreatment strategies involves -

A. Coronal Disassembly and Retreatment Access[30]

Coronal disassembly[31,32] refers to gaining access for retreatment by dismantling existing coronal or radicular restorations. Most endodontically treated teeth receive full-coverage restorations, frequently supported by post-and-core systems, which complicates access compared with minimally restored teeth. The ease and method of restoration removal depend on factors such as preparation design, restorative material composition, luting agent, structural integrity, and the type of removal device employed.

Coronal disassembly devices are grouped as grasping, percussive, and active instruments. Grasping tools apply inward pressure to grip and detach restorations, while percussive devices deliver controlled impact forces either directly on the restoration or via an engaged instrument. Active instruments work through small occlusal openings to generate mechanical removal forces.

1. Post Removal

Post removal is critical in retreating teeth restored with post-and-core systems[33]. The difficulty of post removal depends on post length, diameter, material, design, cement type, and configuration of the head[34]. Among current methods, the piezoelectric ultrasonic system (CPR 1–8) is widely used under dry conditions to maintain visibility and avoid debris slurry formation. Once the post is fully exposed, roto-sonic methods effectively loosen and retrieve it[31]. The PRS kit allows removal when straight-line access and circumferential visibility of the post are achieved[35]. Fiber posts resist conventional retrieval methods such as the Gonon system; instead, Largo burs and Gyrotip instruments that generate controlled heat aid in removal. Ceramic and zirconia posts pose particular challenges due to their brittle or extremely hard composition—ceramic posts can be ground carefully with burs, whereas zirconia's diamond-like hardness precludes conventional removal[31].

2. **Removal of Filling Materials and Access to the Apical Foramen**

During retreatment, access to the apical foramen requires complete removal of previous obturation materials, broadly categorized as pastes/cements, semisolid, and solid materials[31].

i) Pastes and cements vary in solubility: soft materials such as iodoform-based pastes are removed with files or reamers, while hard cements like N-2 or zinc phosphate require ultrasonic fragmentation or careful drilling to avoid perforation. When complete removal is impossible, periradicular surgery may be indicated. Glass ionomer and resin-based sealers like Resilon are particularly resistant.[31,36]

ii) Semisolid materials (gutta-percha) are most common, and removal depends on condensation quality, canal morphology, and obturation length[36,37]. Rotary Ni-Ti files (0.04–0.06 taper) efficiently remove gutta-percha when operated at 1200–1500 RPM, using sequentially sized instruments across canal thirds. Ultrasonic devices soften gutta-percha through frictional heat, allowing coronal movement and removal[37]. Thermal devices such as Touch'n Heat, DownPack, or Endotec pluggers facilitate softening for extraction.[31,37] A combined heat-and-instrument method uses a heated file to engage softened gutta-percha, which can be withdrawn in a single motion—effective in overextended fillings[37].

For narrow or curved canals, chemical softening with chloroform remains the most effective approach. Solvents like eucalyptol, xylene, or halothane are alternatives.[31,38] The technique involves sequential use of small K-files within a chloroform-filled chamber, gradually enlarging until no residue remains. Wicking with paper points absorbs softened gutta-percha and sealers, followed by isopropyl alcohol rinsing[31].

iii) Solid Materials

a) Silver points, used in earlier obturations, are removed more easily when cement seals are weakened by leakage[39]. The apical canal preparation is typically parallel for 2–3 mm, facilitating retrieval using the coronal taper[40]. Cement and restorative material surrounding the silver point are removed using burs with circular cutting ends to create troughs without damaging the cone. Once exposed, silver points are grasped and extracted using Stieglitz or Perry pliers; ultrasonic vibration enhances success in over half of cases[28].

The H-file displacement method within a solvent-filled chamber helps disrupt cement adhesion. Microtube-assisted methods like the PRS system or microtube–H-file combinations provide additional retrieval options[31].

b) Carrier-Based Gutta-Percha Removal

Carrier-based obturation systems employ a solid core (metal or plastic) coated with gutta-percha. Removal requires identifying the carrier type and applying an appropriate strategy. After assessing carrier mobility, ultrasonic tips (CPR-3–5) generate localized heat to thermo soften gutta-percha and loosen carriers. Indirect ultrasonics transmit vibrations via pliers grasping the carrier, while rotary ultrasonics auger plastic carriers when canal space allows[41].

c) Instrument Retrieval and Management of Fractured Instruments

Instrument separation is a frequent procedural complication. Modern visualization and microsontic techniques—combining the dental operating microscope with ultrasonics—enable precise and predictable retrieval. The principle "if you can see it, you can remove it" underscores the importance of magnification[31].

Access creation involves establishing straight-line entry using high-speed burs and sequential enlargement with Gates-Glidden drills in brushing motions. Modified GG drills with truncated tips can form a staging platform around the obstruction, operated at about 300 RPM until contact is achieved[31].

For ultrasonic application, CPR-3–5 tips trephine around obstructions, while smaller CPR-6–8 tips access narrow canals[31].

The Instrument Removal System (IRS) consists of microtubes and wedges for intracanal retrieval. After exposing 2–3 mm of the fractured segment ultrasonically, a suitable microtube is positioned along the canal wall to engage the fragment, and a wedge is rotated clockwise through the lumen to secure and extract it safely[31].

The Cancellier kit uses hollow microtubes (0.50–0.80 mm) and a cyanoacrylate bond to retrieve fractured Ni-Ti instruments, particularly from middle or apical thirds[42]. The Masserann kit employs trepan burs rotating counterclockwise and an extractor sleeve for locking around fragments—effective in straight canals but unsuitable for curved ones due to dentin loss and fracture risk[28].

The Endo Extractor facilitates adhesive-assisted retrieval through bonding and traction[26].Other adjuncts include Endosolve-E, Endosolve-R, and micro debriders designed with offset handles and 0.02 taper blades for precision cleaning of paste residues[26,43].

B. Irrigation Protocols and Intracanal Medicaments[8]

Selecting an appropriate irrigation protocol during retreatment is critical for successful outcomes, as it ensures thorough eradication of residual microbial flora and prevents reinfection. Once the existing restorative materials are removed, meticulous disinfection of the canal system becomes vital for retreatment success. The antimicrobial efficacy of irrigants can be enhanced through the addition of surfactants or by employing activation techniques such as pre-heating, ultrasonic, or sonic agitation, which improve their ability to penetrate dentinal tubules and disrupt biofilms.

Although water-based calcium hydroxide remains widely used, it exhibits limited effectiveness against biofilm-forming bacteria such as Enterococcus faecalis, primarily because of its inability to reach microorganisms deeply located within dentinal tubules. As a supplement, antibiotic-based intracanal medicaments have been used since the 1950s. Among these, the Triple Antibiotic Paste - a combination of ciprofloxacin, metronidazole, and minocycline—has shown a broad antimicrobial spectrum and is particularly effective for managing immature teeth with necrotic pulps or incomplete root development[8].

Studies demonstrate that combining sodium hypochlorite and chlorhexidine with ultrasonic activation yields the most effective irrigation protocol during endodontic retreatment[44].

Outcomes of Contemporary Non-Surgical Retreatment

Modern non-surgical retreatment procedures produce highly favorable results, with periapical healing and success rates between 78% and 87%. Prognosis is influenced by multiple clinical factors, including the absence or small size of preoperative periapical lesions, the quality and length of root fillings, and extended follow-up intervals. These variables together enhance predictability and long-term treatment success[45].

Conclusion

Root canal treatment failure often arises when the procedure fails to meet optimal technical and biological standards. Nevertheless, even adequately performed treatments can fail due to persistent or secondary infections within the root canal system, which compromise periapical healing.

Future Perspectives

Improving retreatment success will rely on emerging technological and material advancements[46]. Cone-Beam Computed Tomography (CBCT) enhances the detection of vertical root fractures and complex canal anatomy, while artificial intelligence (AI) is expected to aid in identifying subtle anatomic and pathologic variations, improving both planning and execution[47]. Future research combining ultrasonic irrigation with newer antimicrobial agents may further improve disinfection efficiency and reduce retreatment failure rates[48]. Continued investigation into bioactive obturation materials capable of promoting tissue regeneration and antimicrobial activity could transform retreatment protocols. Guided endodontics also shows potential for improving precision and reducing complications in non-surgical retreatment; however, as current data are largely in vitro, additional clinical trials are required to confirm these outcomes[49].

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