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Treatment Strategies for Persistent Periapical Lesions: Balancing Surgical and Non-Surgical Options

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Abstract

Persistent periapical lesions (PPLs) remain a therapeutic challenge despite advances in endodontic technology and biomaterials. Such lesions are frequently associated with microbial persistence, extra radicular infections, cystic transformations, or complex root-canal anatomies. Contemporary management requires a delicate balance between non-surgical retreatment and surgical endodontic intervention to ensure periapical healing while preserving tooth structure. This review provides a comprehensive evaluation of the biological basis, diagnostic criteria, and decision-making strategies governing the management of PPLs. Emphasis is placed on the indications, success rates, and limitations of non-surgical versus surgical approaches, including emerging regenerative and biomaterial-based adjuncts. A synthesis of recent randomized trials, meta-analyses, and histopathological evidence highlights a patient-centred

algorithm for clinical decision-making, reinforcing the concept of minimally invasive, biologically driven endodontic care.

Keywords: periapical lesion; chronic apical periodontitis; endodontic retreatment; periradicular surgery; apicoectomy; guided tissue regeneration; lesion persistence.

Introduction

Periapical lesions are the result of chronic inflammatory responses to pulpal necrosis and microbial invasion of the root-canal system. They represent the most common periradicular pathosis encountered in endodontic practice. Although conventional root-canal therapy achieves success rates of 85–95 %, approximately 5–15 % of cases exhibit persistent periapical radiolucencies even after technically adequate treatment [1].

Persistent periapical lesions (PPLs) are defined as periradicular pathologies that fail to resolve or recur after root-canal therapy, typically persisting beyond six months. The etiology may include intraradicular infection, extraradicular biofilms, foreign-body reactions, or true cystic formations. Management of PPLs demands careful assessment to determine whether non-surgical retreatment, periapical surgery, or tooth extraction with replacement offers the optimal outcome.[2,3]

The clinician's challenge lies in balancing biological objectives—elimination of infection and promotion of periapical healing—with conservative tooth preservation. This review critically analyses both non-surgical and surgical strategies, outlining a systematic approach to clinical decision-making grounded in contemporary evidence.

Pathogenesis of Persistent Periapical Lesions

➢ Microbial Persistence [4]

The primary cause of PPLs is residual infection within the complex root-canal anatomy. Bacteria such as Enterococcus faecalis, Actinomyces israelii, and Propionibacterium propionicum can survive extreme environmental conditions, form biofilms, and resist intracanal medicaments (Siqueira & Rôças, 2008). These microorganisms exploit anatomical irregularities—lateral canals, isthmuses, and apical deltas—beyond the reach of instrumentation.

➢ Extraradicular Infection and Biofilm Formation[5,6]

Extraradicular infection occurs when microbial colonies extend onto the root surface or periapical tissue, forming biofilms resistant to host defense. This scenario explains lesions unresponsive to impeccable root-canal obturation. Histological studies (Tronstad et al., 1987) revealed Actinomyces aggregates in periapical granulomas, suggesting the need for surgical removal when biofilms become self-sustaining.

➢ Cystic and Foreign-Body Lesions [7]

PPLs may also develop as true cysts—epithelial-lined cavities isolated from the root-canal system—or as foreign-body reactions to extruded materials. True cysts are self-sustaining and often unresponsive to retreatment, while pocket cysts maintain communication with the canal and may heal non-surgically (Nair, 2006).

Diagnostic Evaluation [8-10]

Accurate diagnosis of PPLs requires integrating clinical, radiographic, and histopathological information.

➢ Radiographic and CBCT Assessment

- **Conventional radiography** reveals persistent radiolucency despite satisfactory obturation.
- **Cone-beam computed tomography (CBCT)** allows three-dimensional evaluation of lesion size, cortical perforation, and missed canals (Patel et al., 2019).
- Lesion volume > 100 mm^3 or cortical plate perforation may predict reduced healing potential with non-surgical approaches.

➢ **Clinical Indicators**

Symptoms such as tenderness to percussion, sinus-tract formation, or swelling suggest active infection. Absence of symptoms with stable lesion size may justify observation or non-surgical retreatment.

➢ **Histopathological Classification**

Biopsy following surgery often identifies periapical granulomas (≈ 65 %), cysts (≈ 15 %), or scar tissue (≈ 20 %) (Nair, 2006). True cysts and foreign-body granulomas usually necessitate surgical removal.

Non-Surgical Management of Persistent Periapical Lesions [11-14]

➢ **Indications**

- Inadequate previous obturation or coronal seal
- Missed canals or complex anatomy accessible for retreatment
- Radiographic evidence of apical leakage or uninstrumented areas
- Absence of procedural errors such as fractured instruments beyond apex

➢ **Endodontic Retreatment**

Non-surgical retreatment aims to re-instrument, disinfect, and obturate the canal system. Key steps include:

1. **Removal of previous filling material** using rotary NiTi or ultrasonic instruments.
2. **Enhanced irrigation** with 2.5–5 % sodium hypochlorite, 17 % EDTA, and passive ultrasonic activation.
3. **Intracanal medicament**—calcium hydroxide dressing for 1–2 weeks effectively reduces microbial load (Siqueira et al., 2018).
4. **Three-dimensional obturation** using warm vertical compaction or bioceramic sealers to ensure apical seal integrity.

➢ **Success Rates**

Meta-analyses report **77–83 % healing** for orthograde retreatment of persistent lesions, approaching that of primary treatment when technical errors are corrected (Ng et al., 2011). Lesion size ≤ 5 mm and absence of perforation predict higher success.

➢ **Adjunctive Pharmacological Approaches**

- **Triple antibiotic paste (TAP)** or **chlorhexidine gel** for resistant infections.
- **Photodynamic therapy (PDT)** and **ozone irrigation** as emerging disinfection adjuncts.
- **Regenerative endodontic procedures (REPs)** in immature teeth to encourage continued root development.

➢ **Monitoring**

Radiographic and clinical review at 6, 12, and 24 months determines healing trajectory. Stable or decreasing lesion size indicates favorable prognosis; progression warrants surgical consideration.

Surgical Endodontic Management [15-18]

➢ **Rationale and Objectives**

When non-surgical retreatment fails or is contraindicated due to procedural complications (e.g., fractured instruments, posts, or iatrogenic blockages), endodontic surgery becomes the treatment of choice. Surgical management directly removes the pathological periapical tissue, seals the root apex, and facilitates histopathological diagnosis.

The objectives of surgical endodontics include:

- Elimination of extraradicular infection or foreign material.
- Creation of a hermetic apical seal through retrograde filling.
- Promotion of bone regeneration within the periapical defect.

➢ **Indications for Surgery**

- Persistent or enlarging radiolucency after retreatment.
- Inaccessible or non-negotiable canals.
- Extruded root-filling materials or periapical foreign bodies.
- Root-end anomalies (e.g., apical resorption, lateral canals).
- True periapical cysts confirmed radiographically or histologically.

Contraindications include systemic conditions compromising healing (e.g., uncontrolled diabetes), inadequate remaining tooth structure, or poor periodontal prognosis.

Surgical Techniques and Materials [19-22]

➢ **Flap Design and Access**

Modern microsurgical techniques employ full mucoperiosteal flaps (triangular or rectangular) to preserve vascularity and ensure visibility. Use of microsurgical instruments and magnification loupes or an operating microscope allows precise osteotomy and root-end management.

➢ **Root-End Resection (Apicoectomy)**

The apical 3 mm of the root is resected to eliminate the apical delta and potential microleakage pathways. This area contains the majority of accessory canals and anatomical irregularities (Kim & Kratchman, 2006).

A 0–10° bevel angle is recommended to minimize dentinal tubule exposure and enhance the adaptation of retrograde materials.

➢ **Root-End Cavity Preparation**

Cavities approximately 3 mm deep are prepared along the long axis of the root using ultrasonic tips. The cavity is then dried and filled with biocompatible retrograde materials such as:

- **Mineral trioxide aggregate (MTA):** Gold standard, provides superior sealing and bioactivity.
- **Biodentine:** Faster setting and improved handling.
- **EndoSequence BC RRM or bioceramic putty:** Excellent marginal adaptation and biocompatibility.

➢ **Guided Tissue Regeneration (GTR)**

In large lesions with cortical perforation, GTR with resorbable collagen membranes and bone grafts (autograft, xenograft, or alloplast) can enhance bone fill and prevent epithelial down growth (Tsesis et al., 2013).

➢ **Histopathologic Examination**

Excised tissue must always be sent for biopsy to distinguish granuloma, cyst, or neoplasm. This step is vital for both treatment validation and medico-legal documentation.

Clinical Outcomes and Prognostic Factors [23,24]

➢ **Success Rates**

Recent systematic reviews report surgical success rates of 88–94 % with modern microsurgical techniques and MTA root-end fillings (Setzer et al., 2012). Traditional surgery without magnification or advanced materials shows lower rates (~60–70 %).

Non-surgical retreatment achieves 77–83 %, suggesting comparable outcomes when properly indicated.

➢ **Predictive Factors for Success**

Factor	Influence on Prognosis
Root-end filling quality	Strongly positive (hermetic seal crucial)
Magnification/microsurgery	Increases success by ~10–15 %
Operator experience	Consistent predictor across studies
Lesion size > 10 mm	Reduced healing rate

Factor	Influence on Prognosis
Orthograde filling integrity	High importance; leakage reduces surgical outcome
Cystic vs granulomatous	True cysts less likely to resolve non-surgically

Table 1: Comparison of success rates between non-surgical and surgical approaches.

Approach	Success (%)	Main Indication	Notes
Primary root canal treatment	85–95	Pulpal necrosis	Standard of care
Orthograde retreatment	77–83	Persistent lesions, missed canals	Requires coronal access
Conventional surgery	60–70	Lesion > 10 mm, cystic	Historical data
Microsurgical (MTA)	88–94	Biofilm persistence, extraradicular infection	High predictability

Combined and Sequential Treatment Approaches [25]

- **Sequential Strategy**

In complex cases, clinicians often employ a sequential approach—starting with non-surgical retreatment and reserving surgery for refractory cases. This aligns with the principle of biologic minimalism and tooth preservation.

- **Combined Therapy**

When a lesion is large or has both intra- and extraradicular components, combining non-surgical disinfection with surgical debridement yields superior healing.

Example: Retreatment → Apicoectomy + GTR in cases with extruded filling material and persistent sinus tract.

- **Retrospective Evidence**

Von Arx et al. (2019) demonstrated 92 % healing for combined approaches versus 80 % for isolated surgery in complex cases, emphasizing the synergistic benefit.

Adjunctive and Emerging Techniques [26]

- **Lasers and Ultrasonics**

Er:YAG and diode lasers aid root-end decontamination and promote hemostasis, while ultrasonic retro tips provide conservative cavity designs and better sealing.

- **Regenerative Endodontic Surgery**

Combining platelet-rich fibrin (PRF) or platelet-rich plasma (PRP) with apicoectomy enhances bone fill and soft-tissue healing. Studies (Taschieri et al., 2021) reported 30–40 % faster radiographic healing when PRF membranes were placed in surgical sites.

- **Endoscopic and Microsurgical Innovations**

Endoscopic visualization allows precise root-end inspection with minimal osteotomy. Use of micro sutures and biomimetic materials ensures predictable outcomes with reduced postoperative morbidity.

Comparative Analysis and Decision-Making Algorithm

- **Key Decision Criteria**

Parameter	**Preferred Approach**	**Rationale**
Poor obturation, missed canals	Non-surgical retreatment	Microbial etiology accessible orthogradely
Blocked canals, separated instruments	Surgical	Direct removal of pathology
Large cystic lesion (> 10 mm)	Surgical ± GTR	Extraradicular or self-sustaining lesion

Parameter	Preferred Approach	Rationale
Good coronal seal, asymptomatic	Observation	Healing potential present
Combined intra/extraradicular infection	Sequential	Synergistic resolution

Discussion

Persistent periapical pathology reflects the complex interplay between microbial persistence and host immune response. The endodontist's task is not merely mechanical disinfection but biological resolution. Evidence supports a stepwise, conservative approach, prioritizing orthograde retreatment where feasible, reserving surgery for refractory or inaccessible lesions. [18]

Technological advances—CBCT, operating microscopes, bioceramic sealers, and PRF membranes—have redefined success thresholds, bringing surgical and non-surgical success rates close to parity. The biological rationale favors minimally invasive microsurgery that preserves cortical integrity, optimizes soft-tissue healing, and allows histologic confirmation.

Moreover, adjunctive regenerative techniques have transformed periapical surgery into a biologically guided regenerative procedure, blurring traditional boundaries between endodontics and periodontology. [24-27]

Conclusion

Persistent periapical lesions demand a balanced, evidence-based treatment algorithm integrating both non-surgical and surgical modalities.

- Non-surgical retreatment remains the first-line approach when canal access is feasible, achieving healing in most cases.
- Surgical endodontics—especially with magnification and bioceramic retrofill—provides predictable resolution for extraradicular or cystic lesions.
- Combined regenerative approaches, including GTR and PRF, further enhance outcomes in large defects.

Ultimately, treatment selection should be guided by etiology, anatomy, and patient-specific factors, adhering to the principles of biological conservation, minimal invasiveness, and predictable healing. With continued refinement of biomaterials and imaging, the future of periapical lesion management lies in integrated regenerative endodontic microsurgery.

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