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Review Article

# Surgical approaches to periapical lesions: Trends and innovations

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ABSTRACT

Periapical lesions, primarily resulting from endodontic infections, represent a significant clinical challenge in dental practice. Surgical intervention is often required when conventional root canal therapy fails to resolve these lesions. This review article examines the current trends and innovations in the surgical management of periapical lesions. It provides a comprehensive analysis of the latest techniques, including periapical curettage, root-end resection, and guided tissue regeneration. Advances in imaging modalities and surgical instruments are also discussed, highlighting their role in enhancing diagnostic accuracy and treatment outcomes. Additionally, the review explores the integration of biomaterials and regenerative approaches aimed at promoting tissue healing and regeneration. By synthesizing contemporary research and clinical experiences, this article aims to offer dental professionals an updated perspective on optimizing surgical strategies for the effective management of periapical lesions.



## 1. Introduction

Periapical lesions are common sequelae of endodontic infections, often presenting as chronic apical periodontitis. These lesions result from the microbial invasion of the root canal system, leading to inflammation and subsequent bone resorption.[1] While conventional root canal therapy (RCT) is the primary treatment modality, it occasionally fails to resolve periapical pathology. In such cases, surgical intervention becomes necessary. This review explores the current trends and innovations in the surgical management of periapical lesions, focusing on advanced techniques, the integration of biomaterials, and regenerative approaches to enhance treatment outcomes.[2]

## 2. Indications for Periapical Surgery

Periapical surgery is indicated in cases where non-surgical endodontic treatment fails or is impractical. Common indications include persistent periapical radiolucency despite adequate RCT, symptomatic apical periodontitis, anatomical complexities preventing effective RCT, presence of a periapical cyst, and the need for biopsy. Other indications encompass cases of iatrogenic errors such as perforations or separated instruments that cannot be retrieved non-surgically. Accurate diagnosis and careful case selection are critical to ensuring the success of surgical interventions.[3]

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### 2.1. Techniques for Periapical Surgery

Modern periapical surgery encompasses a variety of techniques specifically designed to eliminate infection and promote healing in cases where conventional root canal therapy (RCT) fails. The fundamental procedures involved are periapical curettage, root-end resection (apicoectomy), and root-end filling.[4,5]

## 3. Periapical Curettage

Periapical curettage involves the surgical removal of diseased periapical tissues, including granulation tissue, cystic lesions, and any other pathological entities that may be present at the apex of the tooth.[6] This procedure is typically performed under local anesthesia and involves the following steps:

1. Incision and Flap Reflection: A flap is created in the gingival tissue to provide access to the underlying bone and periapical region.
2. Bone Removal: A small window of bone is removed using burs or piezoelectric instruments to expose the periapical area.
3. Curettage: The infected and inflamed tissue is carefully removed using curettes or similar instruments. The area is thoroughly debrided to ensure all pathological tissues are eliminated.

This procedure helps in resolving the infection and inflammation, promoting the natural healing of the periapical region. It is often combined with other surgical procedures such as root-end resection to ensure comprehensive treatment.

## 4. Root-End Resection (Apicoectomy)

Root-end resection, commonly known as apicoectomy, involves the removal of the apical portion of the root along with the surrounding infected tissue. This procedure is indicated when periapical curettage alone is insufficient, or when there are persistent infections or anatomical complexities that impede effective RCT.[7–9] The steps involved in an apicoectomy are as follows:

1. Incision and Flap Reflection: Similar to periapical curettage, a flap is created to expose the bone overlying the root apex.
2. Bone Removal: Bone is removed to gain access to the root apex.
3. Root-End Resection: Approximately 3-4 mm of the root tip is resected using burs or ultrasonic tips. This excision helps to remove the apical delta and any persistent infection that may be present in the root canal.[10]
4. Root-End Preparation: A small cavity is prepared at the resected root end using ultrasonic tips to facilitate the placement of a root-end filling material.[11]

This technique is crucial for eliminating the source of infection and preventing recurrence. It also provides a clean, accessible surface for the subsequent root-end filling.

## 5. Root-End Filling

Root-end filling is a critical component of periapical surgery, aimed at creating a hermetic seal at the resected root end to prevent microbial leakage and promote periapical healing. Materials commonly used for root-end fillings include mineral trioxide aggregate (MTA) and bioceramics due to their superior sealing properties and biocompatibility.[12] The steps involved are:

1. Cavity Preparation: After the root-end resection, a small cavity is prepared at the resected end using ultrasonic tips.
2. Filling Material Placement: The cavity is then filled with a suitable material such as MTA or bioceramics. These materials are chosen for their ability to provide a tight seal and their compatibility with the surrounding tissues.
3. Final Sealing: The filling is compacted and sealed, ensuring there are no gaps through which bacteria could penetrate.

The use of advanced materials like MTA and bioceramics has significantly improved the success rates of apicoectomy by enhancing the sealing ability and promoting tissue regeneration.[13]

## 6. Advances in Surgical Instruments

The precision and success rates of periapical surgeries have been significantly improved with advancements in surgical instruments. Some of the key innovations include:

1. Ultrasonic Tips: These are used for precise bone removal, root-end resection, and preparation of the root-end cavity. Ultrasonic tips provide better control, reduced trauma to the surrounding tissues, and improved outcomes compared to traditional burs.
2. Magnification Devices: Operating microscopes and loupes allow for enhanced visualization of the surgical field. The increased magnification helps in identifying and treating anatomical complexities, ensuring complete removal of pathological tissues, and accurate placement of root-end fillings.
3. Piezoelectric Instruments: These instruments utilize ultrasonic vibrations to cut bone with minimal damage to soft tissues. They are particularly useful in delicate areas where precision is paramount.[14]

## 7. Integration of Biomaterials and Regenerative Approaches

### *7.1. Biomaterials in periapical surgery*

#### *7.1.1. Mineral trioxide aggregate (MTA)*

1. Properties: MTA is a hydrophilic powder that sets in the presence of moisture, forming a dense and stable matrix. It is highly biocompatible, has excellent sealing properties, and promotes tissue regeneration.
2. Applications: MTA is commonly used for root-end fillings, perforation repairs, and as a pulp-capping material. Its ability to create a hermetic seal prevents microbial leakage, promoting periapical healing.[15]

#### *7.1.2. Bioceramics*

1. Properties: Bioceramics, including calcium silicate-based materials, are known for their biocompatibility, bioactivity, and osteoconductive properties. They bond well with dental tissues and promote the formation of hydroxyapatite, which is essential for bone regeneration.
2. Applications: Bioceramics are used for root-end fillings, apical plugs, and as sealing materials in various endodontic procedures. Their bioactive nature enhances the healing of periapical tissues and supports bone regeneration.[16]

## 8. Regenerative Approaches in Periapical Surgery

### *8.1. Platelet-rich plasma (PRP)*

1. Properties: PRP is derived from the patient's own blood and contains a high concentration of growth factors that promote tissue healing and regeneration. These growth factors include platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), and vascular endothelial growth factor (VEGF).
2. Mechanism: PRP accelerates the healing process by enhancing cell proliferation, collagen synthesis, and angiogenesis (formation of new blood vessels). It also reduces inflammation and promotes the formation of granulation tissue.
3. Applications: PRP can be applied to surgical sites to enhance soft tissue and bone healing. It is particularly useful in cases where extensive tissue regeneration is required.[17]

### *8.2. Stem cell therapy*

1. Properties: Stem cells have the unique ability to differentiate into various cell types, making them ideal for regenerative therapies. Mesenchymal stem cells (MSCs) derived from bone marrow, dental pulp, or adipose tissue are commonly used in dental applications.
2. Mechanism: When applied to the surgical site, stem cells differentiate into osteoblasts (bone-forming cells), fibroblasts (collagen-producing cells), and other cell types essential for tissue regeneration. They also secrete bioactive molecules that promote healing and modulate the immune response.
3. Applications: Stem cell therapy is used in regenerative endodontics to restore the structure and function of the pulp-dentin complex. It can also enhance bone regeneration in periapical defects, improving the overall treatment outcomes.[18]

## 9. Guided Tissue Regeneration (GTR)

1. Properties: GTR involves the use of barrier membranes to direct the growth of new bone and periodontal tissues. These membranes prevent the ingrowth of unwanted tissues, allowing the selective regeneration of desired tissues.
2. Mechanism: The barrier membranes create a protected environment for the proliferation and differentiation of progenitor cells into osteoblasts and other regenerative cells. This selective regeneration promotes the formation of new bone and periodontal structures.
3. Applications: GTR is used in periapical surgery to enhance bone regeneration and periodontal healing. It is particularly beneficial in cases with significant bone loss or complex anatomical defects.[18]

## 10. Clinical Applications and Outcomes

The integration of biomaterials and regenerative approaches in periapical surgery has led to significant improvements in clinical outcomes. These innovations offer several advantages, including:

1. Enhanced Healing: Biomaterials like MTA and bioceramics provide excellent sealing and biocompatibility, promoting faster and more effective healing of periapical tissues.
2. Bone Regeneration: Bone grafts and regenerative techniques like PRP and stem cell therapy support the regeneration of periapical bone, restoring the structural integrity of the surgical site.
3. Reduced Inflammation: PRP and stem cell therapy help reduce inflammation and promote the formation of healthy tissue, improving overall healing.
4. Improved Success Rates: The use of advanced biomaterials and regenerative approaches has increased the success rates of periapical surgeries, leading to better long-term outcomes and patient satisfaction.

Bone Grafts: Autografts, allografts, and synthetic grafts are utilized to fill bony defects and support the regeneration of periapical tissues.

Regenerative endodontics aims to restore the functional properties of the pulp-dentin complex through tissue engineering principles. Techniques such as platelet-rich plasma (PRP) and stem cell therapy are being explored to enhance periapical tissue regeneration and improve clinical outcomes. [19]

## 11. Future Directions

The future of periapical surgery lies in the continued development of minimally invasive techniques, advanced biomaterials, and regenerative therapies. Research is ongoing to improve the efficacy and predictability of surgical interventions. Innovations such as nanotechnology, 3D printing, and gene therapy hold promise for further enhancing periapical healing and regeneration. Additionally, the integration of artificial intelligence and digital imaging is expected to revolutionize diagnosis, treatment planning, and intraoperative precision. [20]

## 12. Conclusion

Surgical management of periapical lesions has evolved significantly, with advancements in techniques, biomaterials, and regenerative approaches contributing to improved clinical outcomes. The integration of these innovations into clinical practice enables dental professionals to effectively manage complex periapical pathologies, ensuring optimal patient care. Continued research and technological advancements will further refine these approaches, offering new possibilities for enhancing periapical health and treatment success.

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## 14. Conflict of Interest

None.

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