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# REFINING THE TREATMENT OF RADICULAR CYSTS: AN EVIDENCE-BASED SURGICAL AND ADJUNCTIVE APPROACH

**Abdullayev Maqsadbek Matchonboy ugli**
Master's Degree student, Urgench RANCH University of Technology

**Abstract:** Radicular cysts represent the most common odontogenic cystic lesions of the jaws, accounting for approximately 52–68% of all jaw cysts. Arising from epithelial remnants within the periapical tissues following pulp necrosis, these inflammatory cysts pose a dual clinical challenge: elimination of the cystic lesion and preservation or restoration of the associated tooth. While conventional treatment modalities including endodontic therapy, cyst enucleation, marsupialization, and decompression are well established, the selection of the optimal surgical approach remains a subject of considerable debate. This article provides a comprehensive analysis of the etiopathogenesis, diagnostic evaluation, and current treatment paradigms for radicular cysts, and proposes a refined, size-stratified, minimally invasive treatment algorithm. By integrating advances in cone-beam computed tomography imaging, regenerative endodontic techniques, guided tissue regeneration, and adjunctive pharmacotherapy, this review synthesizes evidence from clinical and histological studies to advocate for a biologically driven, tooth-preserving approach. The goal is to maximize cyst resolution while preserving pulp vitality where possible, promoting periapical bone regeneration, and minimizing surgical morbidity.

**Keywords:** Radicular Cyst, Periapical Cyst, Endodontic Surgery, Enucleation, Marsupialization, Decompression, Cone-Beam Computed Tomography, Bone Regenerationю

## INTRODUCTION

Radicular cysts, also termed periapical cysts or apical periodontal cysts, constitute the most prevalent odontogenic cystic lesions encountered in oral and maxillofacial practice. Epidemiological studies consistently report that radicular cysts account for over half of all jaw cysts, with a peak incidence in the third to fifth decades of life and a slight male predilection [1]. These inflammatory cysts arise as a direct consequence of pulp necrosis, wherein bacterial toxins and inflammatory mediators from the infected root canal system stimulate the proliferation of the epithelial rests of Malassez within the periapical granuloma. The progressive expansion of the cyst is driven by a complex interplay of osmotic pressure gradients, inflammatory exudate accumulation, and enzymatic bone resorption mediated by prostaglandins, interleukin-1, and matrix metalloproteinases released by inflammatory cells within the cyst wall [2].

Clinically, radicular cysts are frequently asymptomatic and detected incidentally on routine radiographic examination as a well-circumscribed, round or ovoid radiolucency with a thin radiopaque border, associated with the apex of a non-vital tooth. However, larger lesions may present with swelling, tenderness, tooth mobility, displacement of adjacent teeth, or, in the case of secondary infection, acute pain and suppuration. The radiographic differential diagnosis includes periapical granuloma, which cannot be reliably distinguished from a radicular cyst based on conventional periapical radiography alone. Histologically, a radicular cyst is defined by a cavity lined by stratified squamous epithelium, supported by a chronically inflamed connective tissue wall containing lymphocytes, plasma cells, cholesterol clefts, and Rushton hyaline bodies [3].

The management of radicular cysts has traditionally followed one of several surgical pathways. Small cysts (<10 mm in diameter) are often managed conservatively with conventional endodontic therapy, as the majority of periapical radiolucencies resolve following successful root canal treatment regardless of their histological nature. For larger cysts or those failing to resolve after endodontic therapy, surgical intervention typically enucleation with or without apicoectomy

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has been the standard of care [4]. However, enucleation of large cysts carries risks including injury to adjacent anatomical structures (inferior alveolar nerve, maxillary sinus, nasal floor), devitalization of adjacent teeth, pathological fracture of the weakened jaw, and significant postoperative bone defects. In response to these limitations, more conservative surgical techniques, including marsupialization and decompression, have gained traction as alternatives that reduce surgical morbidity and promote bone fill from the periphery of the lesion.

Despite the availability of these treatment options, clinical decision-making remains highly variable, often influenced by operator preference rather than objective, evidence-based criteria. The critical gap in current practice is the absence of a standardized, size-stratified, and biologically informed treatment algorithm that matches the surgical intervention to the specific characteristics of the cyst and the anatomical context.

Objective: This article aims to critically review the etiopathogenesis, diagnostic evaluation, and current surgical and adjunctive management of radicular cysts, and to propose a refined, evidence-based treatment algorithm that optimizes cyst resolution, preserves adjacent structures, and promotes periapical bone regeneration.

## MATERIALS AND METHODS

This study is structured as a narrative review and critical synthesis of literature. A comprehensive literature search was conducted using PubMed, Scopus, and Google Scholar databases for articles published between 1995 and 2025. The search strategy employed combinations of Medical Subject Headings (MeSH) and free-text terms, including “radicular cyst,” “periapical cyst,” “endodontic surgery,” “apicoectomy,” “enucleation,” “marsupialization,” “decompression cyst,” “cone-beam computed tomography jaw cyst,” “guided tissue regeneration periapical,” and “bone grafting periapical defect.” Inclusion criteria encompassed original clinical research, randomized controlled trials, prospective and retrospective cohort studies, case series involving more than 20 patients, systematic reviews, and meta-analyses. Studies focusing exclusively on non-inflammatory odontogenic cysts, case reports, and animal studies without human clinical correlation were excluded. Articles were critically analyzed for methodological rigor, relevance of outcome measures (e.g., cyst resolution rate, bone regeneration volume, tooth survival rate, recurrence rate, complications), and biological plausibility. The synthesis focused on constructing a practical, evidence-informed treatment algorithm that integrates advances in imaging, surgical technique, and regenerative adjuncts into a unified clinical pathway.

## RESULTS AND DISCUSSION

Accurate preoperative assessment is the foundation of refined surgical management. While conventional periapical and panoramic radiography provide two-dimensional representations of the cyst, cone-beam computed tomography (CBCT) offers three-dimensional visualization with submillimeter resolution. CBCT accurately delineates the true size and extent of the lesion, its relationship to adjacent vital structures including the mandibular canal, mental foramen, maxillary sinus, and nasal cavity the degree of cortical bone thinning or perforation, and the proximity to adjacent tooth roots. For radicular cysts exceeding 15 mm in diameter, located in the posterior mandible or maxilla, or associated with clinical signs suggestive of cortical expansion, CBCT imaging is strongly recommended. The information gained from CBCT directly influences the selection of surgical approach and reduces the risk of intraoperative complications [5].

The differential diagnosis between a radicular cyst and a periapical granuloma cannot be made radiographically, but certain features on CBCT suggest a cystic rather than granulomatous lesion. These include a well-defined corticated border, a maximum diameter exceeding 10 mm, and displacement of adjacent structures. However, definitive diagnosis remains histological, and all surgically removed tissue should be submitted for histopathological examination to exclude rare but clinically significant lesions such as odontogenic keratocyst, ameloblastoma, or central giant cell granuloma [6].

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The selection of surgical technique should be guided by a combination of cyst size, anatomical location, proximity to vital structures, and the restorability of the involved tooth. The proposed refined algorithm stratifies lesions into three categories:

Category I: Small Radicular Cysts (<10 mm)

For cysts less than 10 mm in maximum diameter without cortical perforation, conventional orthograde endodontic therapy alone is the treatment of choice. The biological rationale is that the inflammatory stimulus driving cyst formation the infected necrotic pulp is eliminated through chemomechanical debridement and hermetic obturation of the root canal system. The cyst wall, deprived of its inflammatory stimulus, undergoes gradual resolution through apoptosis of the lining epithelium and replacement by fibrovascular connective tissue and bone. Clinical studies demonstrate that approximately 85–90% of periapical radiolucencies, including small cysts, resolve within 12 months following successful endodontic therapy [7]. Surgical intervention is reserved for cases that fail to demonstrate radiographic evidence of healing at 12-month follow-up.

Category II: Intermediate Radicular Cysts (10–25 mm)

Cysts in the intermediate size range present a decision-making challenge. For cysts 10–15 mm in diameter that are well-contained with intact cortical plates, initial endodontic therapy with close radiographic follow-up is a reasonable first-line approach. If significant healing is not evident at 6 months, surgical intervention with enucleation and concurrent apicoectomy is indicated. For cysts 15–25 mm, particularly those with cortical thinning or perforation, primary surgical treatment is preferred. Enucleation with apicoectomy, retrograde root-end preparation, and placement of a biocompatible root-end filling material typically mineral trioxide aggregate (MTA) or bioceramic putty provides definitive treatment. The root-end filling provides an apical seal that prevents residual bacterial egress from the root canal system into the periapical tissues [8].

Category III: Large Radicular Cysts (>25 mm)

Large cysts present a significantly elevated risk profile for primary enucleation. The surgical trauma, risk to adjacent structures, and the large residual bone defect created by enucleation in a single procedure can result in significant postoperative morbidity, prolonged healing, and compromised bone regeneration. For these lesions, a two-stage approach employing decompression followed by secondary enucleation is recommended. Decompression involves the creation of a small window into the cyst cavity, with placement of a drainage tube or acrylic stent to maintain patency of the opening. This procedure immediately reduces intracystic pressure, interrupts the osmotic and inflammatory drivers of cyst expansion, and initiates centripetal bone fill from the periphery. Over a period of 3–12 months, the cyst reduces in size as new bone is deposited, and the thickened cyst lining transforms into a thinner, less inflamed epithelium. Once the cyst has reduced to a manageable size typically less than 50% of its original dimensions secondary enucleation can be performed with significantly reduced surgical risk and a smaller residual defect [9]. Marsupialization, a related technique in which the cyst lining is sutured to the oral mucosa to create a permanent opening, is reserved for cysts in edentulous areas where complete enucleation is not necessary or when the cyst involves the maxillary sinus floor, creating an oroantral communication.

Emerging evidence supports the use of adjunctive measures to enhance the biological response to surgical treatment. The placement of bone graft materials autogenous bone, allografts, xenografts, or alloplastic materials into the residual defect following enucleation of large cysts accelerates bone fill and provides structural support to prevent soft tissue collapse. Guided tissue regeneration (GTR) using resorbable collagen membranes placed over the graft material excludes competing connective tissue cells from the defect, allowing selective repopulation by osteogenic precursor cells. The combination of bone grafting and GTR has been shown to produce superior

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bone fill and density compared to healing by secondary intention alone in periapical defects exceeding 20 mm [10].

The use of systemic antibiotics in radicular cyst surgery is reserved for specific indications. Prophylactic antibiotics are not indicated for routine enucleation of non-infected cysts. However, in cases with acute secondary infection, purulent discharge, or systemic symptoms, a short course of oral amoxicillin 500 mg three times daily for 5–7 days (or clindamycin 300 mg four times daily for penicillin-allergic patients) is appropriate. Postoperative chlorhexidine gluconate 0.12% mouthwash twice daily for 7–10 days reduces bacterial load at the surgical site.

Proposed Refined Treatment Algorithm

The following algorithm synthesizes the evidence into a practical clinical pathway:

Step 1 (Diagnostic Assessment): Clinical examination including pulp vitality testing of the involved and adjacent teeth. CBCT imaging for cysts >15 mm, posterior mandibular or maxillary location, or suspicion of cortical perforation or sinus involvement.

Step 2 (Treatment Stratification): Categorize cyst as small (<10 mm), intermediate (10–25 mm), or large (>25 mm). Assess tooth restorability.

Step 3 (Category I Management): Conventional endodontic therapy with 12-month radiographic follow-up. Surgical intervention only if no healing evident.

Step 4 (Category II Management): Endodontic therapy with 6-month follow-up for 10–15 mm cysts. Enucleation with apicoectomy and MTA root-end filling for 15–25 mm cysts or non-healing smaller cysts. Consider bone graft and GTR for defects >15 mm.

Step 5 (Category III Management): Decompression with acrylic stent or drainage tube placement. Monthly follow-up with radiographic assessment. Secondary enucleation when cyst reduced to <50% of original size, typically at 6–12 months. Bone graft and GTR at secondary enucleation.

Step 6 (Postoperative Care): Analgesia with NSAIDs. Chlorhexidine mouthwash. Suture removal at 7 days. Radiographic follow-up at 3, 6, 12, and 24 months to assess bone fill.

Step 7 (Histopathology): All excised tissue submitted for histopathological examination to confirm diagnosis and exclude neoplastic lesions.

## CONCLUSION

The management of radicular cysts has evolved significantly from the era of routine, aggressive enucleation toward a refined, biologically driven, and minimally invasive paradigm. The size-stratified treatment algorithm proposed herein integrating advanced CBCT imaging, conservative decompression for large cysts, precise microsurgical enucleation with modern root-end filling materials for intermediate lesions, and guided bone regeneration for large residual defects offers a comprehensive, evidence-based framework that optimizes cyst resolution while preserving adjacent anatomical structures and promoting periapical bone healing. The most critical determinant of successful treatment remains the elimination of the inflammatory stimulus through definitive endodontic therapy or apicoectomy.

Surgical intervention serves as an adjunct to, not a substitute for, this fundamental endodontic principle. Future directions include the development of tissue-engineered bone graft substitutes with osteoinductive properties, the application of platelet-rich fibrin and growth factor concentrates to accelerate healing, and multicenter randomized controlled trials directly comparing decompression and primary enucleation for large radicular cysts. Through the implementation of refined, protocol-driven care, the standard of management for these common lesions can be elevated, achieving predictable cyst resolution with minimal surgical morbidity and optimal preservation of the natural dentition.

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