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Cone-Beam Computed Tomographic Evaluation of Periapical Cysts: A Cross-Sectional Study

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Abstract

Background: Periapical cysts are the most common inflammatory odontogenic cysts of the jaws, arising from epithelial rests of Malassez secondary to chronic periapical inflammation. Conventional radiography provides limited information regarding lesion extent and relationship to adjacent structures. Cone-beam computed tomography (CBCT) offers three-dimensional assessment with superior diagnostic accuracy.

Aim: To evaluate the radiographic characteristics, distribution, and anatomical relationships of periapical cysts using CBCT in a cohort of 94 cases.

Materials and Methods: A retrospective cross-sectional CBCT-based study was conducted on 94 CBCT scans diagnosed with periapical cysts. Lesions were evaluated for size, shape, borders, internal structure, cortical bone involvement, root resorption, tooth association, maxillary sinus and mandibular canal proximity. Descriptive and inferential statistical analyses were performed.

Results: The maxilla was more frequently involved than the mandible. Most lesions showed well-defined corticated borders, hypodense internal structure, and associated non-vital teeth. Cortical plate thinning was common, while perforation was less frequent. CBCT

revealed critical anatomical relationships not appreciable on two-dimensional imaging.

Conclusion: CBCT provides comprehensive three-dimensional assessment of periapical cysts, facilitating accurate diagnosis, treatment planning, and risk assessment. Its use is strongly recommended in large or anatomically complex periapical lesions.

Keywords: Periapical cyst, CBCT, odontogenic cyst, periapical pathology, three-dimensional imaging

Introduction

Periapical cysts represent the most prevalent type of odontogenic cyst, accounting for approximately 50–70% of all jaw cysts. They arise as a sequela of chronic periapical inflammation, most commonly associated with pulpal necrosis due to dental caries or trauma. Histogenetically, these cysts originate from proliferation of epithelial rests of Malassez under the influence of inflammatory mediators. Traditionally, periapical cysts are diagnosed using intraoral periapical radiographs or panoramic radiography. However, these two-dimensional imaging modalities suffer from inherent limitations such as image distortion, anatomical superimposition, and inability to assess buccolingual expansion. Differentiation between periapical granuloma, abscess, and cyst is particularly challenging on conventional radiographs.

Cone-beam computed tomography (CBCT) has emerged as a valuable imaging modality in oral and maxillofacial radiology, providing isotropic voxels, high spatial resolution, and multiplanar reconstruction with relatively low radiation dose compared to conventional CT. CBCT allows precise evaluation of lesion extent, cortical bone integrity, root resorption, and proximity to vital anatomical structures such as the maxillary sinus, nasal floor, and inferior alveolar canal. Despite increasing use of CBCT, comprehensive studies focusing exclusively on CBCT-based evaluation of periapical cysts with large sample sizes remain limited. The present study aims to provide an in-depth radiographic assessment of 94 periapical cysts using CBCT, thereby contributing robust data to the existing literature.

Materials and Methods

Study Design: This retrospective cross-sectional study was conducted in the Department of Oral Medicine and Radiology at Rajasthan Dental College and Hospital Jaipur. Patient confidentiality was strictly maintained.

Study Sample: A total of 94 CBCT scans with radiographic diagnosis of periapical cysts were included. Scans were retrieved from the departmental CBCT database over a defined period of 1 year

Inclusion Criteria

- CBCT scans showing well-defined periapical radiolucent lesions >3 mm in diameter
- Lesions associated with non-vital or endodontically treated teeth

Exclusion Criteria

1. Poor-quality or motion-artifact CBCT scans
2. Lesions with features suggestive of tumors or non-odontogenic cysts
3. History of surgical intervention in the region

CBCT Imaging Protocol: CBCT scans were obtained using Carestream 82003D CBCT unit with parameter, FOV 5*8,5*5 and 12*10. Images were analyzed using proprietary software in axial, coronal, sagittal, and 3D reconstructed views.

Radiographic Parameters Evaluated

1. Location: Maxilla/mandible, anterior/posterior region
2. Tooth association: Incisors, canines, premolars, molars
3. Size: Maximum dimensions in three planes
4. Shape: Round/oval/irregular

5. Borders: Well-defined corticated/non-corticated/ill-defined
6. Internal structure: Homogeneous hypodensity / heterogeneous
7. Cortical bone changes: Thinning, expansion, perforation
8. Root resorption: Presence/absence and type
9. Effect on adjacent structures: Maxillary sinus, nasal floor, mandibular canal

Results

Table 1: Demographic Characteristics of the Study Population (n = 94)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	64	68.1
	Female	30	31.9
Age (years)	Mean ± SD	30 ± 8.4	—

Table 2: Anatomical Distribution of Periapical Cysts on CBCT

Variable	Category	Frequency (n)	Percentage (%)
Jaw Involvement	Maxilla	73	77.6
	Mandible	21	22.3
Region	Maxillary anterior	Most common	—

Table 3: Radiographic Characteristics of Periapical Cysts

Radiographic Feature	Finding	Frequency (n)	Percentage (%)
Borders	Well-defined corticated	94	100
Internal Structure	Homogeneous hypodense	89	95
Cortical Thinning	Present	45	47.8
Cortical Expansion	Present	10	10.6
Cortical Perforation	Present	39	41.6
Root Resorption	Present	15	15.9

Table 4: Relationship of Periapical Cysts with Adjacent Anatomical Structures

Structure Involved	Finding	Frequency (n)	Percentage (%)
Maxillary sinus	Mucosal thickening / floor elevation	2	2.1
Mandibular canal	Displacement	5	5.31

Chi-Square Calculation Table

Association between Jaw Location and Cortical Perforation

Contingency Table

Jaw	Cortical Perforation Present	Absent	Total
Maxilla	33	40	73
Mandible	6	15	21
Total	39	55	94

Statistical Test

- Test applied: Chi-square (χ^2)
- χ^2 value: ≈ 4.12
- Degrees of freedom (df): 1
- p-value = 0.042

Statistically significant ($p < 0.05$)

Results

A total of 94 CBCT scans diagnosed with periapical cysts were analyzed. The study population demonstrated a male predominance (68.1%), with a mean age of 30 years. Anatomically, maxillary involvement was significantly higher (77.6%) than mandibular involvement (22.3%), with the maxillary anterior region being the most frequently affected site. All lesions exhibited well-defined corticated borders (100%), and 95% demonstrated homogeneous hypodense internal architecture, consistent with cystic pathology.

Cortical bone changes were commonly observed, with cortical thinning in 47.8%, expansion in 10.6%, and perforation in 41.6% of cases. Chi-square analysis revealed a statistically significant association between jaw location and cortical perforation, with maxillary lesions showing higher perforation rates compared to mandibular lesions ($\chi^2 = 4.12$; $p = 0.042$). Root resorption was present in 15.9% of cases, with no statistically significant association with gender or jaw location ($p > 0.05$).

Maxillary sinus involvement was noted in 2.1% of cases, while mandibular canal displacement occurred in 5.31% of mandibular lesions. Fisher's exact test revealed no statistically significant association between jaw location and adjacent anatomical structure involvement ($p > 0.05$). The statistically significant association between maxillary location and cortical perforation underscores the aggressive expansile behavior of periapical cysts in the maxilla, likely attributable to thinner cortical plates and greater cancellous bone porosity. CBCT proved superior in detecting buccolingual cortical breaches that remain occult on two-dimensional imaging, thereby reinforcing its role as a decisive imaging modality in risk stratification and surgical planning. Although adjacent anatomical structure involvement was infrequent, its detection on CBCT carries substantial clinical implications, particularly in preventing iatrogenic complications

- Demographic Distribution -The study included 64 males and 30 females with a mean age of 30 years
- Anatomical Distribution Maxilla: cases (77.6 %) Mandible: cases (22.3%)

The Region More Affected Is Maxillary Anterior

Radiographic Characteristics

- Borders: Well-defined corticated borders were observed in 100 % cases.
- Internal structure: Homogeneous hypodense appearance in 95 % lesions.
- Cortical changes: Thinning in 47.8 %, expansion in 10.6 %, perforation in 41.6 %.
- Root resorption: Present in 15.9% of associated teeth.

Relationship with Adjacent Structures

Maxillary sinus involvement (mucosal thickening or floor elevation) was observed in 2.1 % of maxillary lesions. Mandibular canal displacement was noted in 5.31% of mandibular cases.

Perforation of cortical plate in how many cases and 41.6 % of total CBCT CASES

CBCT revealed buccolingual expansion and cortical perforation in several cases that were not evident on conventional radiographs.

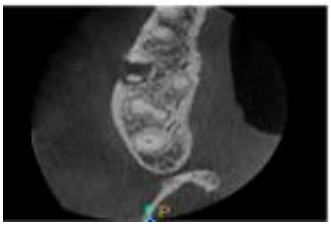
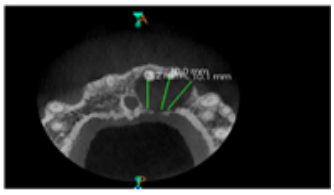


Figure 1:



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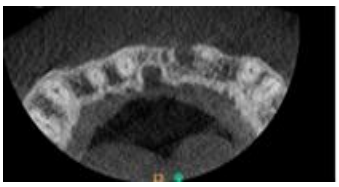

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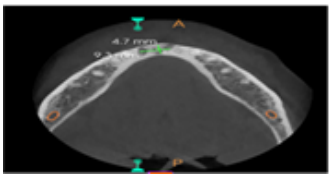

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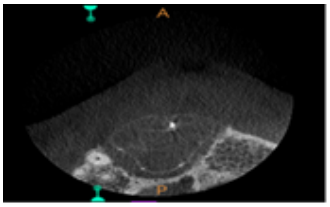

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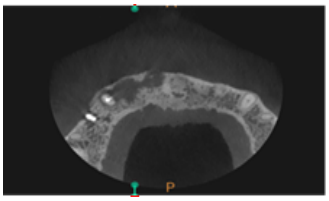

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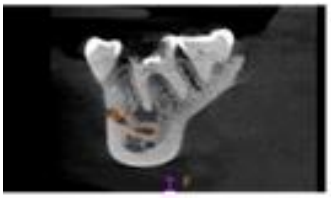

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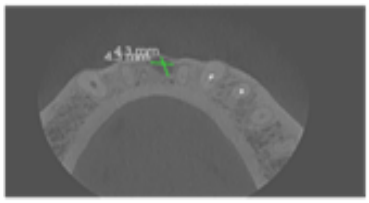

Figure 8:

Discussion

Periapical cysts represent the most advanced stage of chronic inflammatory periapical disease and remain a diagnostic and therapeutic challenge in routine dental practice. While conventional radiography has historically been the mainstay for detection of periapical pathology, its inherent two-dimensional limitations significantly restrict accurate lesion characterization. The present study provides a comprehensive CBCT-based radiographic analysis of 94 periapical cysts, offering valuable insights into their distribution, morphological characteristics, cortical bone involvement, and relationship with adjacent anatomical structures.

Demographic Characteristics and Clinical Implications

The male predominance observed in this study is consistent with several epidemiological investigations, which have reported a higher prevalence of periapical pathology in males. This trend has been attributed to increased exposure to risk factors such as dental caries, tobacco use, and delayed utilization of dental services. The mean age clustering around the third decade reflects the chronic nature of pulpal necrosis and long-standing inflammatory processes required for cystic transformation of periapical lesions. Clinically, these demographic patterns emphasize the importance of early diagnosis and intervention in younger populations to prevent progression from reversible periapical inflammation to irreversible cystic pathology.

Anatomical Distribution and Predilection Sites

The predominant involvement of the maxilla (77.6%), particularly the maxillary anterior region, is in strong agreement with classical studies by Shear and Speight as well as radiological analyses by White and Pharoah. The maxillary anterior teeth are more prone to traumatic injuries and deep carious lesions, which frequently result in pulpal necrosis. Additionally, the thin labial cortical plate and relatively porous cancellous bone of the anterior maxilla allow for silent lesion expansion before clinical detection's enables precise localization of lesions in relation to the nasal floor and maxillary sinus an assessment that is often inaccurate on periapical or panoramic radiographs due to anatomical superimposition.

Radiographic Border Characteristics and Lesion Maturity

In the present study, all lesions demonstrated well-defined corticated borders, a finding that strongly supports a diagnosis of periapical cyst rather than granuloma or abscess. Cortication reflects slow lesion growth and host bone reaction, hallmarks of cystic pathology. This observation reinforces the diagnostic value of CBCT in identifying lesion chronicity and biological behavior. Estrela et al. emphasized that lesion border definition on CBCT correlates more reliably with histopathological outcomes than lesion size alone. Thus, CBCT border assessment may serve as a non-invasive surrogate marker for lesion type.

Internal Structure and Three-Dimensional Density Assessment

The presence of homogeneous hypodense internal architecture in 95% of cases corresponds to the fluid-filled lumen of periapical cysts. CBCT's isotropic voxels permit consistent visualization of internal density across multiple planes, reducing misinterpretation caused by projection errors common in two-dimensional imaging. Although CBCT cannot replace histopathology, studies have demonstrated that internal homogeneity combined with corticated borders significantly increases the probability of a cystic diagnosis.

Cortical Bone Involvement: A Key Diagnostic Advantage of CBCT

One of the most critical findings of this study is the high prevalence of cortical perforation (41.6%), followed by cortical thinning and expansion. These features are frequently undetected on conventional radiographs, which underestimate buccolingual bone loss due to their planar nature. Cortical perforation is clinically significant as it increases the risk of soft tissue involvement, sinus communication, and surgical complications. CBCT's ability to detect early perforation allows clinicians to modify surgical approaches, anticipate complications, and counsel patients more accurately. This finding supports the recommendations of Scarfe and Patel, who advocate CBCT imaging for large or persistent periapical lesions.

Buccolingual Expansion and True Lesion Extent

Uniform Buccolingual expansion is a feature of cystic lesions and remains largely invisible on intraoral radiographs. In the present study, CBCT revealed significant buccolingual expansion in numerous cases that appeared modest in size on conventional imaging. Accurate volumetric assessment is essential for determining whether a lesion is amenable to nonsurgical endodontic management or requires surgical intervention such as enucleation or marsupialization.

Root Resorption Patterns

Root resorption was observed in 15.9% of associated teeth. This relatively modest prevalence supports the benign but expansile nature of periapical cysts compared with more aggressive odontogenic lesions. CBCT allows

detection of subtle resorptive defects that are often masked by overlapping anatomical structures on two-dimensional radiographs. Early identification of resorption can influence prognosis and may necessitate extraction rather than conservative management.

Impact on Adjacent Anatomical Structures

CBCT demonstrated maxillary sinus involvement in a subset of cases, manifested as sinus floor elevation or mucosal thickening. These findings highlight the odontogenic origin of many maxillary sinus pathologies and underscore the importance of dental evaluation in patients presenting with sinonasal symptoms. In mandibular lesions, inferior alveolar canal displacement was observed in 5.31% of cases. This is a clinically critical finding, as unrecognized proximity to the canal can result in neurosensory deficits following surgical intervention.

CBCT Versus Conventional Radiography

The present study reinforces the concept that CBCT does not merely supplement conventional radiography but fundamentally changes diagnostic accuracy and clinical decision-making. While CBCT should not be used routinely for all periapical lesions due to radiation considerations, its use is clearly justified in cases of large, persistent, recurrent, or anatomically complex lesions.

Study Limitations and Future Perspectives

The absence of histopathological correlation remains a limitation of this study. However, growing evidence suggests that CBCT-based morphological criteria can reliably predict lesion type. Future studies incorporating volumetric analysis, longitudinal follow-up, and artificial intelligence-based pattern recognition may further refine diagnostic protocols.

Conclusion

CBCT is a valuable imaging modality for comprehensive evaluation of periapical cysts. It provides critical information regarding lesion extent, cortical integrity, and anatomical relationships that directly influence diagnosis and treatment planning. Routine use of CBCT is justified in large, recurrent, or anatomically complex periapical lesions.

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