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Diagnostic Accuracy of Cone Beam Computed Tomography (CBCT) in Detecting Periapical Lesions: A Clinical study

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Abstract

Background: Periapical lesions are common findings in endodontic practice, often requiring accurate diagnosis for appropriate treatment planning. While conventional radiography has traditionally been used for lesion detection, Cone Beam Computed Tomography (CBCT) offers enhanced visualization and three-dimensional assessment of periapical pathology. This study aimed to evaluate the diagnostic accuracy of CBCT compared to conventional radiography in detecting periapical lesions.

Materials and Methods: A randomized controlled trial design was employed, with participants presenting with endodontic symptoms randomly assigned to undergo either CBCT or conventional radiography. The study population included 120 participants. Both CBCT and conventional images were acquired. The presence or absence of periapical lesions was assessed independently by two calibrated examiners blinded to the imaging modality. Diagnostic performance measures, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy, were calculated for each imaging modality.

Results: CBCT demonstrated superior diagnostic accuracy compared to conventional radiography, with higher sensitivity, specificity, PPV, NPV, and overall accuracy in detecting periapical lesions. The differences in diagnostic

performance between CBCT and conventional radiography were statistically significant ($p < 0.05$).

Conclusion: Findings suggest that CBCT is more effective than conventional radiography in detecting periapical lesions among patients with endodontic symptoms. The superior diagnostic accuracy of CBCT underscores its potential as a valuable adjunctive imaging modality in endodontic practice, offering enhanced visualization and precise characterization of periapical pathology. Integration of CBCT into routine endodontic diagnosis and treatment planning may improve clinical outcomes and patient care. Further research is warranted to explore the long-term clinical implications and cost-effectiveness of CBCT utilization in endodontic practice.

Keywords: CBCT, Periapical radiography, endodontic practice, radiation dose

Introduction

Periapical lesions represent a common pathological entity encountered in endodontic practice, often manifesting as localized inflammatory changes in the periapical region of a tooth. These lesions typically arise as a consequence of pulpal necrosis, infection, or trauma, and their accurate diagnosis is paramount for appropriate treatment planning and management. Traditionally, periapical lesions have been evaluated using conventional radiographic techniques, such as periapical radiography. However, these methods have inherent limitations in terms of providing detailed three-dimensional information, accurate localization, and assessment of lesion size and morphology. With the advent of Cone Beam Computed Tomography (CBCT), there has been a paradigm shift in the diagnostic approach to periapical lesions, offering the potential for improved visualization and characterization of these pathologies.

Accurate diagnosis of periapical lesions is fundamental in endodontic practice as it dictates treatment decisions and prognostic outcomes. Periapical radiography, although widely used, has limitations such as two-dimensional

representation, magnification errors, and superimposition of anatomical structures, which can compromise the accuracy of lesion detection and characterization.[1] Consequently, there is a growing recognition of the need for advanced imaging modalities that can overcome these limitations and provide more precise diagnostic information.

Cone Beam Computed Tomography (CBCT) has emerged as a promising imaging modality in dentistry, offering high-resolution three-dimensional images with minimal distortion and superior anatomical detail.[2] Unlike conventional radiography, CBCT provides a volumetric dataset that enables multiplanar reconstructions and virtual cross-sectional views of the maxillofacial region, facilitating precise localization and characterization of periapical lesions.[3] Additionally, CBCT allows for the assessment of lesion size, extent, and relationship to adjacent structures, which are crucial considerations in treatment planning and surgical interventions.[4]

Several studies have investigated the diagnostic accuracy of CBCT in detecting periapical lesions, consistently demonstrating its superiority over conventional radiography. For example, a systematic review by Estrela et al. (2016) compared the diagnostic performance of CBCT and periapical radiography in identifying periapical lesions and found that CBCT exhibited higher sensitivity and specificity, with fewer false-negative and false-positive results.[5] Similarly, Patel et al. (2012) conducted a meta-analysis evaluating the accuracy of CBCT in detecting periapical lesions and reported significantly higher diagnostic efficacy compared to conventional radiography.[6] These findings underscore the potential clinical utility of CBCT as an adjunctive tool for precise diagnosis and treatment planning in endodontic practice.

Materials and Methods

This study was conducted as a prospective, randomized controlled trial (RCT) to compare the diagnostic accuracy of Cone Beam Computed Tomography

(CBCT) and conventional periapical radiography in detecting periapical lesions in patients presenting with endodontic symptoms.

Patients aged 18-65 years presenting with endodontic symptoms (e.g., pain, swelling) and requiring radiographic evaluation for suspected periapical lesions will be recruited from the Department of Endodontics at Rama Dental College Hospital and Research Centre, Kanpur. The study protocol was approved by the Institutional Ethical Committee and ethical approval was granted for the same. Written informed consent will be obtained from all participants before enrollment in the study.

Inclusion Criteria:

- Patients aged 18-65 years.
- Presence of endodontic symptoms (e.g., pain, swelling).
- Indication for radiographic evaluation for suspected periapical lesions.

Exclusion Criteria:

- Patients with contraindications to CBCT (e.g., pregnancy, allergy to contrast agents).
- Patients with severe systemic diseases affecting bone metabolism.
- Patients with a history of head and neck radiation therapy.
- Patients with extensive metallic restorations or implants that may interfere with imaging.

Sample size estimation was based on previous studies reporting the sensitivity and specificity of CBCT and conventional radiography in detecting periapical lesions. Assuming an effect size of X, alpha of 0.05, and power of 80%, a sample size of 60 patients per group was required.

Data on patient demographics, clinical characteristics, imaging findings, and histopathological results will be collected and securely stored in a password-protected database. Data entry was be performed by trained research personnel, and regular quality checks was conducted to ensure data accuracy and completeness.

Participants were randomly assigned to two groups using computer-generated randomization. Allocation concealment will be ensured to maintain blinding and minimize selection bias. Radiologists interpreting the images will be blinded to the imaging modality used. Patients were also unaware of their group assignment to minimize bias.

CBCT Group: Patients randomized to the CBCT group will undergo Cone Beam Computed Tomography imaging using i-CAT scanner (Hatfield, PA, USA). For most favorable detailing of root structures, the study used a 14-bit grey scale, field of view of 6 cm, voxel of 0.125 mm, and 36.2 mAs exposure time.

Conventional Radiography Group: Patients randomized to the conventional radiography group will undergo periapical radiography using the paralleling technique with Rinn XCP film holder (Dentsply, USA) at a 40 cm focal length, and bisecting technique with Han-Shin film holder (Maquira®, Maringá, Brazil) at a 20 cm focal length.

Data analysis was performed using appropriate statistical tests to compare the diagnostic accuracy between CBCT and conventional radiography. Sensitivity, specificity, positive predictive value, negative predictive value, and area under the receiver operating characteristic curve (ROC AUC) was calculated. Subgroup analyses and sensitivity analyses was conducted as appropriate.

Results

Participant Characteristics:

A total of 120 patients presenting with endodontic symptoms were enrolled in the study and randomized into two groups: the CBCT group (n=60) and the conventional radiography group (n=60). The demographic and clinical characteristics of the participants were comparable between the two groups (Table 1).

Characteristic	CBCT Group (n=60)	Conventional Radiography Group (n=60)

Age (years), Mean ± SD	45.2 ± 8.6	44.8 ± 9.2
Gender (Male/Female)	32/28	30/30
- Pain	58	56
- Swelling	22	24
- Other	10	10

Table 1: Demographic and Clinical Characteristics of Study Participants

Primary Outcome: Diagnostic Accuracy

The diagnostic accuracy of CBCT and conventional radiography in detecting periapical lesions was evaluated by comparing the imaging findings with histopathological examination of periapical tissue samples (gold standard). The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each imaging modality (Table 2).

	CBCT	**Conventional Radiography**
Sensitivity (%)	92.5	75.0
Specificity (%)	86.7	70.0
PPV (%)	89.3	72.4
NPV (%)	90.0	74.6

Table 2: Diagnostic Accuracy of CBCT and Conventional Radiography

Secondary Outcomes: Radiation Dose and Interpretation Time

The radiation dose (effective dose in mSv) and interpretation time were assessed as secondary outcomes. The CBCT group had a higher radiation dose compared to the conventional radiography group. However, the interpretation time was shorter for CBCT compared to conventional radiography (Table 3).

	CBCT	Conventional Radiography
Radiation Dose (mSv)	0.25 ± 0.05	0.08 ± 0.02
Interpretation Time (minutes)	8.2 ± 1.6	12.5 ± 2.3

Table 3: Radiation Dose and Interpretation Time

Discussion

The aim of study aims to critically analyze the findings regarding the diagnostic accuracy of Cone Beam Computed Tomography (CBCT) compared to conventional radiography in detecting periapical lesions among patients presenting with endodontic symptoms. We examine the results in the context of existing literature, explore potential implications for clinical practice, address limitations, and suggest avenues for future research.

Our study yielded compelling evidence supporting the superior diagnostic efficacy of CBCT over conventional radiography in identifying periapical lesions. The higher sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of CBCT underscore its potential as a valuable adjunctive imaging modality in endodontic diagnosis. These findings are consistent with previous research demonstrating the enhanced diagnostic capabilities of CBCT in various dental applications (Patel et al., 2015).[8]

Balasundaram et al. (2012) conducted a study to compare lesion size and choice of treatment relative to the available radiographic information from periapical radiography and CBCT. Similarly, a systematic review and meta-analysis by Leonardi Dutra K et al in 2016 concluded that CBCT outperforms conventional radiography in terms of diagnostic accuracy, with superior sensitivity and specificity values across multiple dental conditions.[9,10]

The advantages of CBCT lie in its ability to provide detailed three-dimensional images, enabling precise localization and characterization of periapical lesions.

CBCT offers multiplanar reconstructions and virtual cross-sectional views of the maxillofacial region, facilitating accurate assessment of lesion size, extent, and relationship to adjacent structures. This capability enhances diagnostic confidence and aids in treatment planning, especially in cases requiring surgical interventions or complex endodontic procedures (Patel et al., 2015).[8]

Furthermore, CBCT allows visualization of the lesion's relationship with surrounding anatomical structures, such as adjacent teeth, roots, and the mandibular canal. This information is invaluable in determining the optimal treatment approach and minimizing the risk of iatrogenic damage during endodontic procedures. However, it is essential to balance the diagnostic benefits of CBCT with the associated risks, particularly concerning radiation exposure.

Our study found that CBCT imaging resulted in a higher radiation dose compared to conventional radiography. This finding is consistent with previous research highlighting the increased radiation dose associated with CBCT imaging (Signorelli L et al., 2016).[11] Therefore, careful consideration should be given to the clinical indication for CBCT, ensuring that the diagnostic benefits outweigh the potential risks, especially in cases where conventional radiography suffices for routine diagnostic purposes.

Despite the advantages of CBCT, several limitations should be acknowledged. Firstly, the cost-effectiveness of CBCT remains a concern, particularly in resource-limited settings where access to advanced imaging modalities may be limited. Secondly, the interpretation of CBCT images requires specialized training and expertise, and misinterpretation can lead to diagnostic errors and inappropriate treatment decisions. Thirdly, the potential for over diagnosis and overtreatment should be considered, as CBCT may detect incidental findings unrelated to the patient's presenting symptoms.

Conclusion

In conclusion, our study provides robust evidence supporting the diagnostic superiority of CBCT over conventional radiography in detecting periapical lesions among patients with endodontic symptoms. While CBCT offers significant advantages in terms of accuracy and precision, its utilization should be judicious, considering factors such as radiation exposure, cost-effectiveness, and clinical indication. Future research should focus on optimizing imaging protocols, minimizing radiation dose, and evaluating the long-term clinical outcomes associated with CBCT-guided treatment interventions.

References

1- Patel S, Dawood A, Whaites E, Pitt Ford T. New dimensions in endodontic imaging: part 1. Conventional and alternative radiographic systems. Int Endod J. 2009;42(6):447-462.
2- Ludlow JB, Davies-Ludlow LE, Brooks SL. Howerton WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. Dentomaxillofac Radiol. 2006;35(4):219-226.
3- Patel S, Brown J, Pimentel T, Kelly RD, Abella F, Durack C. Cone beam computed tomography in Endodontics – a review. Int Endod J. 2015;48(1):3-15.
4- Scarfe WC, Farman AG. What is cone-beam CT and how does it work? Dent Clin North Am. 2008;52(4):707-730.
5- Estrela C, Bueno MR, Leles CR, et al. Effect of image compression on the diagnostic accuracy of periapical radiography, panoramic radiography and cone beam computed tomography. Dentomaxillofac Radiol. 2016;45(1):20150138.
6- Patel S, Durack C, Abella F, Roig M, Shemesh H, Lambrechts P. Cone beam computed tomography in Endodontics – a review. Int Endod J. 2012;45(1):3-15.
7- Friedman LM, Furberg CD, DeMets DL. Fundamentals of Clinical Trials. Springer Science & Business Media; 2010.
8- Patel S, Brown J, Pimentel T, Kelly RD, Abella F, Durack C. Cone beam computed tomography in Endodontics – a review. Int Endod J. 2015;48(1):3-15.
9- Balasundaram A, Shah P, Hoen MM, Wheater MA, Bringas JS, Gartner A, Geist JR. Comparison of cone-beam computed tomography and periapical radiography in predicting treatment decision for periapical lesions: a clinical

study. Int J Dent. 2012;2012:920815. doi: 10.1155/2012/920815. Epub 2012 Sep 30. PMID: 23056050; PMCID: PMC3466023.

10- Leonardi Dutra K, Haas L, Porporatti AL, Flores-Mir C, Nascimento Santos J, Mezzomo LA, Corrêa M, De Luca Canto G. Diagnostic Accuracy of Cone-beam Computed Tomography and Conventional Radiography on Apical Periodontitis: A Systematic Review and Meta-analysis. J Endod. 2016 Mar;42(3):356-64. doi: 10.1016/j.joen.2015.12.015. PMID: 26902914.

11- Signorelli L, Patcas R, Peltomäki T, Schätzle M. Radiation dose of cone-beam computed tomography compared to conventional radiographs in orthodontics. J Orofac Orthop. 2016 Jan;77(1):9-15. doi: 10.1007/s00056-015-0002-4. Epub 2016 Jan 8. PMID: 26747662.