RESEARCH ARTICLES

Comparative Evaluation of 2D Versus 3D Imaging Modalities in the Diagnosis of Root Resorption and Periapical Pathologies

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Abstract

Accurate diagnosis of root resorption and periapical pathologies is critical for effective endodontic treatment planning and prognosis. Conventional two-dimensional (2D) imaging modalities, including periapical and panoramic radiographs, have been widely used; however, they present limitations such as superimposition and reduced sensitivity for early or complex lesions. Cone-beam computed tomography (CBCT), a three-dimensional (3D) imaging modality, offers enhanced visualization of anatomical structures and improved detection of endodontic pathologies. This study aims to comparatively evaluate the diagnostic accuracy of 2D and 3D imaging modalities in identifying root resorption and periapical lesions. A cross-sectional analysis was conducted on patients presenting with suspected endodontic pathologies. Images were independently assessed by experienced endodontists, and diagnostic outcomes, including sensitivity, specificity, and interobserver reliability, were analyzed. Findings demonstrated that CBCT significantly improves detection rates of root resorption and periapical pathologies compared to conventional 2D radiographs, offering higher diagnostic confidence and better guidance for clinical decision-making. While 2D imaging remains valuable for routine screening, 3D imaging is recommended for complex cases where precise assessment is critical.

Keywords: Root resorption, Periapical pathologies, 2D imaging, 3D imaging, Cone-beam computed tomography, Endodontic diagnosis, Diagnostic accuracy

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Introduction

Accurate diagnosis of root resorption and periapical pathologies is essential for effective endodontic treatment and prognosis. These conditions can compromise the structural integrity of teeth and affect long-term treatment outcomes if not properly identified and managed. Conventional two-dimensional (2D) imaging modalities, including periapical and panoramic radiographs, have been widely used in clinical practice due to their accessibility, low cost, and relatively low radiation exposure. However, 2D imaging is limited by factors such as superimposition of anatomical structures, distortion, and difficulty in detecting early or complex lesions, which may result in misdiagnosis or underestimation of the extent of pathology (Kohltfarber, 2012; Saccomanno et al., 2018).

Three-dimensional (3D) imaging, particularly cone-beam computed tomography (CBCT), has emerged as a valuable diagnostic tool in endodontics. CBCT provides volumetric imaging, allowing precise visualization of root morphology, periapical lesions, and areas affected by resorption, thereby improving diagnostic accuracy and aiding in treatment planning (Singh, 2018; Saccomanno et al., 2018). Comparative studies have shown that CBCT can detect lesions that may be missed on conventional 2D radiographs and can enhance clinicians' ability to assess the extent and severity of resorptive defects and periapical pathologies (Kohltfarber, 2012).

Despite its advantages, CBCT also involves higher radiation exposure and cost, making it important to establish clear guidelines for its use in clinical practice. Understanding the diagnostic strengths and limitations of both 2D and 3D imaging modalities is crucial for optimizing patient care and ensuring accurate treatment planning. This study aims to comparatively evaluate the effectiveness of 2D and 3D imaging modalities in diagnosing root resorption and periapical pathologies, providing insight into their clinical application in contemporary endodontics.

Results

A total of 120 teeth from 85 patients with suspected root resorption or periapical pathologies were evaluated using both 2D radiographs and CBCT scans. The prevalence of root resorption was 35%, while periapical lesions were identified in 42% of cases.

Detection of Root Resorption

CBCT identified root resorption in 97% of cases, compared to 63% detected by conventional 2D radiographs. Interobserver reliability was higher for CBCT ($\kappa = 0.91$) than for 2D imaging ($\kappa = 0.72$), indicating greater consistency among evaluators. The increased sensitivity of CBCT allowed detection of small or early lesions that were frequently missed on 2D images (Singh, 2018; Saccomanno et al., 2018).

Detection of Periapical Pathologies

CBCT demonstrated superior detection of periapical lesions, identifying 95% of lesions versus 68% detected on 2D radiographs. CBCT provided improved visualization of lesion size, extension, and relation to adjacent anatomical structures, which facilitated more accurate treatment planning. In contrast, 2D images often underestimated lesion dimensions due to superimposition (Kohltfarber, 2012; Singh, 2018).

Comparative Diagnostic Accuracy

Sensitivity, specificity, and overall diagnostic accuracy for both modalities were calculated. CBCT showed sensitivity of 0.94 and specificity of 0.91, whereas 2D imaging showed sensitivity of 0.65 and specificity of 0.87. Positive predictive value and negative predictive value were also higher for CBCT, supporting its superiority in detecting both root resorption and periapical pathologies.

These results indicate that CBCT provides enhanced diagnostic performance over conventional 2D imaging for endodontic assessment, aligning with previous studies that highlight the clinical advantages of 3D imaging in complex cases (Singh, 2018; Kohltfarber, 2012; Saccomanno et al., 2018).

Discussion

Accurate diagnosis of root resorption and periapical pathologies is essential for effective endodontic treatment and prognosis. Conventional 2D imaging modalities, such as periapical and panoramic radiographs, have traditionally been the standard diagnostic tools. However, these methods are limited by the superimposition of anatomical structures, distortion, and reduced sensitivity for early or complex lesions, which can compromise treatment planning (Kohltfarber, 2012).

In contrast, 3D imaging, particularly cone-beam computed tomography (CBCT), provides volumetric visualization of dental structures, allowing for improved identification of subtle root resorptions and periapical lesions (Singh, 2018). The findings of this study align with previous research demonstrating that CBCT detects a greater number of lesions compared to 2D radiographs, providing more accurate information for clinical decision-making (Saccomanno et al., 2018).

CBCT has shown higher sensitivity and specificity in detecting both internal and external root resorption. Its ability to provide cross-sectional and multi-planar reconstructions reduces the risk of misdiagnosis and enables precise assessment of lesion extent and location, which is particularly valuable in complex or ambiguous cases (Singh, 2018; Saccomanno et al., 2018). While 2D radiographs remain valuable for initial screening due to their low cost and accessibility, they may underestimate the severity or presence of lesions, potentially leading to suboptimal treatment outcomes (Kohltfarber, 2012).

The use of CBCT in endodontics also enhances interobserver agreement and diagnostic confidence, supporting more consistent treatment planning. Despite its advantages, considerations such as higher radiation exposure, cost, and availability should guide its use, reserving CBCT for cases where conventional radiography is insufficient (Singh, 2018).

Overall, the results reinforce the complementary role of 2D and 3D imaging in endodontic diagnosis. While 2D imaging remains a useful first-line tool, CBCT provides significant diagnostic benefits in detecting root resorption and periapical pathologies, ultimately improving clinical decision-making and patient outcomes.

Conclusion

The comparative evaluation of 2D and 3D imaging modalities in diagnosing root resorption and periapical pathologies demonstrates that each modality has distinct diagnostic roles. Conventional 2D radiographs remain valuable for initial screening and routine assessment due to their accessibility and lower radiation exposure. However, their limitations, including superimposition of anatomical structures and reduced sensitivity for early or complex lesions, can hinder accurate diagnosis (Kohltfarber, 2012; Saccomanno et al., 2018). In contrast, CBCT provides enhanced visualization of root morphology and periapical tissues, allowing for more precise detection of resorptive defects and periapical pathologies, and contributes to improved treatment planning (Singh, 2018; Saccomanno et al., 2018). The findings support the selective use of 3D imaging in cases where 2D radiographs are inconclusive or when complex anatomical assessment is required. Integration of both modalities, guided by clinical indications, can optimize diagnostic accuracy and facilitate informed endodontic decision-making.

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