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RADIOGRAPHIC ASSESSMENT OF IMPACTED THIRD MOLARS: DIAGNOSTIC TOOLS, INDICATIONS, AND CLINICAL RELEVANCE

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ABSTRACT

The evaluation of impacted third molars—commonly known as wisdom teeth—requires accurate imaging to guide diagnosis, treatment planning, and surgical intervention. Radiographic examinations play a central role in determining the position, angulation, root formation, and proximity of third molars to vital anatomical structures such as the inferior alveolar nerve and maxillary sinus. Panoramic radiography has long been the most commonly used imaging modality due to its comprehensive field of view and low radiation exposure. However, technological advancements have increased the use of cone beam computed tomography (CBCT), especially in complex cases where detailed three-dimensional (3D) information is essential. This paper reviews current radiographic techniques for assessing impacted third molars, comparing their indications, diagnostic capabilities, limitations, and relevance to surgical decision-making. Recent literature emphasizes that while panoramic radiography remains sufficient in most routine cases, CBCT offers superior accuracy in evaluating the spatial relationship between the mandibular third molar roots and the mandibular canal, significantly reducing the risk of inferior alveolar nerve injury. Moreover, periapical and occlusal radiographs may complement panoramic findings in selected cases, offering high-resolution images of specific regions. Guidelines from international dental organizations now support a risk-based approach to imaging, reserving CBCT for cases with high anatomical complexity or unclear findings in conventional images. The purpose of this article is to present an updated overview of radiographic methods available for the evaluation of impacted third molars, highlighting their diagnostic value, clinical indications, and role in minimizing surgical complications. Emphasis is placed on evidence-based imaging protocols that optimize diagnostic yield while adhering to radiation safety principles, such as ALARA (As Low As Reasonably Achievable).

Keywords: Impacted third molars. Panoramic radiography. Cone beam computed tomography. Inferior alveolar nerve. Radiographic evaluation.

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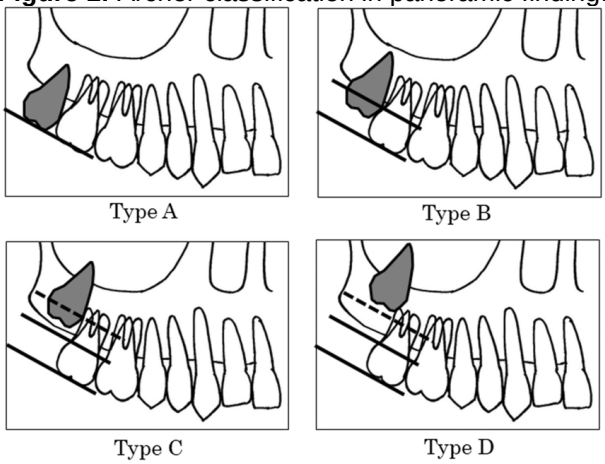
INTRODUCTION

Impacted third molars, more commonly referred to as wisdom teeth, are developmental anomalies frequently encountered in dental practice. Their prevalence is high across global populations, with studies indicating impaction rates ranging from 20% to 30% depending on ethnicity, genetic factors, and jaw development. These teeth, typically the last to erupt, often face spatial limitations in the posterior segments of the maxilla and mandible, resulting in partial or complete impaction. Clinically, impacted third molars can be asymptomatic or associated with a variety of pathological conditions, including pericoronitis, second molar root resorption, dental crowding, deep carious lesions, localized periodontal destruction, and odontogenic cysts or tumors.

Radiographic evaluation serves as the cornerstone for assessing the status of these teeth. It allows clinicians to determine critical parameters such as the angulation of eruption (mesioangular, distoangular, vertical, or horizontal), depth of impaction, stage of root development, degree of follicular space enlargement, and, crucially, the spatial relationship to vital anatomical structures such as the mandibular canal and the maxillary sinus. These radiographic findings are indispensable in formulating surgical strategies and anticipating potential intraoperative or postoperative complications.

The Archer classification for panoramic findings is as follows: Type A: the maxillary third molar is at or below the occlusal plane. Type B: the maxillary third molar is located between the occlusal plane and the cervical line. Type C: the maxillary third molar is situated between the cervical line of the second molar and the middle third of its root. Type D: the maxillary third molar is at or above the apical third of the second molar's root.

Figure 1: Archer classification in panoramic finding.



Source: Iwata, 2021.

Traditionally, panoramic radiography has been the first-line imaging technique due to its wide availability, low radiation exposure, and ability to capture the entire dentition in a single image. However, its two-dimensional limitations—such as distortion, magnification, and overlap—can hinder accurate localization, particularly in complex anatomical regions. In contrast, cone beam computed tomography (CBCT) provides volumetric 3D data that enhances diagnostic precision, especially in cases involving close proximity of mandibular third molars to the inferior alveolar nerve (IAN) or maxillary impactions near the sinus cavity. Despite its advantages, CBCT must be prescribed judiciously due to higher radiation doses and cost, and its use should align with diagnostic necessity and the ALARA principle.

Moreover, a comprehensive radiographic evaluation may also incorporate periapical, bitewing, or occlusal radiographs to supplement information in selected cases. The integration of multiple modalities can offer a more holistic view, enabling clinicians to better assess surgical complexity and reduce the risk of complications such as nerve injury, excessive bone removal, or postoperative infections.

The aim of this article is to provide a comprehensive review of radiographic techniques used in the assessment of impacted third molars, critically analyzing their clinical indications, diagnostic accuracy, and implications for safe and effective surgical management.

The evaluation of impacted third molars has been the subject of numerous academic studies aimed at optimizing diagnosis and minimizing complications during surgical procedures. Panoramic radiography has traditionally been the technique of choice for this purpose; however, new technologies such as Cone Beam Computed Tomography (CBCT) and Artificial Intelligence (AI) have proven promising for more accurate and detailed assessments.

The Archer classification has been widely used to categorize the position of third molars in panoramic radiographs. A study conducted by Mubarak and Tajrin (2024) evaluated the agreement between panoramic radiography and CBCT in the classification of impacted lower third molars. The results indicated that while panoramic radiography is effective in most cases, CBCT provides a more detailed view of the anatomy, allowing for more precise surgical planning. This study recommended the use of CBCT when the relationship between third molars and the inferior alveolar nerve is not clearly visible on panoramic radiographs.

Regarding the use of artificial intelligence, a study conducted by Jaron et al. (2021) investigated the application of AI in detecting and classifying impacted third molars on panoramic radiographs. The study aimed to assess the accuracy of AI algorithms compared to evaluations performed by experienced professionals. The results showed that AI models achieved an accuracy of up to 90%, demonstrating considerable efficiency in identifying patterns and classifying third molars quickly and accurately. The authors suggested that AI could become a complementary tool for radiologists, especially in high-volume imaging settings where manual analysis may be more prone to errors.

Another important study conducted by Peker et al. (2014) compared panoramic radiography and CBCT in diagnosing third molar impactions. The research aimed to determine which technique offers greater accuracy in evaluating the spatial relationship between impacted teeth and the inferior alveolar nerve. The study concluded that while panoramic radiography is effective in most cases, CBCT provides a more detailed view of the anatomy, enabling more precise surgical planning. The study recommended the use of CBCT when the relationship between the third molars and the inferior alveolar nerve is not clearly visible on panoramic radiographs.

Finally, a study by Kuang et al. (2023) investigated the relationship between the position of third molars and the risk of injury to the inferior alveolar nerve. The objective was to analyze whether certain characteristics, such as the inclination of the teeth, could indicate a greater proximity to the nerve. The results showed that tooth angulation—especially in cases with a more horizontal position or significant buccolingual inclination—was correlated with an increased risk of inferior alveolar nerve injury. The study recommended that such cases be evaluated with greater caution, using techniques like CBCT to accurately map the spatial relationship between the third molar and the nerve.

The analysis of the reviewed studies highlights the significant evolution of diagnostic tools used for the evaluation of impacted third molars. Traditional panoramic radiography remains a widely adopted clinical practice due to its accessibility, low cost, and availability. However, growing evidence points to its limitations, particularly when assessing the three-dimensional relationship of anatomical structures.

The study by Mubarak et al. (2024) emphasizes the superior diagnostic accuracy of Cone-Beam Computed Tomography (CBCT) when there is uncertainty about the

proximity between the third molar and the inferior alveolar nerve. CBCT's ability to provide detailed three-dimensional imaging eliminates the overlapping of structures that often compromises panoramic radiographs, allowing for safer and more precise surgical planning. This finding is supported by Peker et al. (2014), who highlight the importance of choosing the appropriate imaging modality based on the complexity of each case and its associated surgical risks.

On the other hand, the incorporation of artificial intelligence (AI) into radiographic analysis represents a promising advancement. The work of Jaron et al. (2024) demonstrates that AI algorithms can achieve accuracy levels comparable to experienced professionals. This automation not only reduces image analysis time but also minimizes human error, especially in high-volume clinical settings. AI emerges as a complementary tool, enhancing diagnostic efficiency and supporting radiologists in their decision-making processes.

Furthermore, the study by Kuang et al. (2023) adds a critical dimension to this discussion by demonstrating a direct correlation between specific positional and angular characteristics of impacted molars and the risk of inferior alveolar nerve injury. This observation underscores the importance of identifying morphological risk predictors and reinforces the need for advanced diagnostic methods like CBCT in high-risk cases.

Collectively, these findings indicate a clear trend toward integrating modern technologies—such as CBCT and AI—into conventional clinical practices. Selecting the most appropriate diagnostic approach must consider factors such as anatomical visibility, surgical risk, technological availability, and cost-effectiveness, always prioritizing patient safety.

This review demonstrates that while panoramic radiography continues to serve as a widely accessible and cost-effective diagnostic resource, it often lacks the structural resolution required for precise assessment of impacted third molars. The two-dimensional nature of panoramic imaging, combined with anatomical superimposition and limited sensitivity in detecting the proximity to the inferior alveolar nerve, can compromise surgical planning and increase the likelihood of complications.

In this context, Cone-Beam Computed Tomography (CBCT) emerges as a highly reliable diagnostic tool. It offers high-resolution, three-dimensional images that allow clinicians to evaluate complex anatomical relationships with greater precision. CBCT is particularly valuable when assessing close proximity to the mandibular canal or

identifying complex root morphology, and its use is strongly recommended whenever panoramic radiography is inconclusive, especially in high-risk cases involving potential neurosensory damage.

Additionally, the integration of artificial intelligence (AI) in radiographic analysis represents a major technological leap. AI algorithms have demonstrated high accuracy in pattern recognition and classification tasks, complementing the work of radiologists and enhancing diagnostic efficiency. These technologies reduce interpretation time and variability, and they hold potential for use as educational and clinical support tools, fostering greater diagnostic consistency and quality in dental practice.

The studies reviewed also underscore the importance of specific morphological features—such as buccolingual inclination or horizontal orientation—as predictors of inferior alveolar nerve injury. These findings highlight the necessity of a risk-oriented diagnostic strategy that leverages clinical expertise, anatomical understanding, and advanced technologies.

In conclusion, modern dental practice concerning the evaluation and treatment of impacted third molars should be guided by a strategic integration of advanced technologies like CBCT and AI with sound clinical judgment and experience. This combination offers the potential to significantly enhance diagnostic accuracy, surgical safety, and clinical outcomes. The future of diagnostic dentistry lies in the intelligent adoption of these tools, which requires not only technological investment but also the continuous education and training of professionals to ensure ethical, critical, and efficient application of these innovations.

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