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Imaging Impacted Teeth: The Evolving Role of Oral Radiology in Diagnosis and Treatment Planning

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ABSTRACT

Impacted teeth are common in oral surgery and orthodontics, and their management depends on accurate localization, assessment of adjacent structures, and estimation of treatment difficulty. This review summarizes the role of oral radiology in the treatment of impacted teeth and discusses how imaging aids in surgical and orthodontic decision-making while balancing diagnostic benefit against radiation exposure. Conventional two-dimensional imaging remains the first-line approach for many impacted teeth because it is widely available and often adequate for initial assessment. Its main limitation is poor visualization of the spatial relationship of the impacted teeth to cortical plates and nearby vital structures, especially the inferior alveolar nerve and adjacent roots. CBCT addresses these shortcomings by providing three-dimensional assessment of tooth position, angulation, anatomical relationships, and probable surgical difficulty, and it appears particularly useful when panoramic findings suggest proximity to the mandibular canal, when maxillary canine impaction is complex, or when root resorption is suspected. MRI is an emerging radiation-free option that can display impacted teeth and surrounding structures, but current evidence remains limited, protocols are not standardized, and artefacts or hardware constraints can reduce feasibility.

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Current evidence supports a stepwise imaging strategy in which the least arduous modality capable of answering the clinical question is used first, and advanced imaging is reserved for justified complex cases. Oral radiology improves diagnosis, guides treatment planning, helps anticipate complications, and supports multidisciplinary care.

***Keywords*:** Impacted tooth, Radiography, Dental, Cone-Beam Computed Tomography, Panoramic Radiography, Oral Surgical Procedures, Orthodontics, Tooth Extraction.

1. INTRODUCTION

Impacted teeth are common in oral surgery and orthodontics, and their successful management depends on accurate localization, assessment of adjacent structures, and evaluation of treatment difficulty level (1–3). This review emphasizes the significance of oral radiology in the management of impacted teeth, with reference to periapical radiography, panoramic radiography, cone beam computed tomography (CBCT), and new magnetic resonance imaging (MRI) techniques. It also describes how imaging guides surgical and orthodontic decisions by weighing the diagnostic benefit against radiation exposure (2,4,5). Such a diverse clinical topic spans orthodontics, oral surgery, dentomaxillofacial radiology, and emerging imaging technologies rather than one narrow intervention question (6–8) demanding a narrative review as they can synthesize heterogeneous evidence and interpret across different imaging modalities, indications and practice settings (6,7,9). However, good narrative reviews still require a clear scope, transparent search boundaries, and critical synthesis rather than simple description (6,10,11) which means that the intent must be stated explicitly, methodology of evidence search need to be described and the review must focus on clinically relevant themes such as the diagnosis, management and prognosis (7,9,12).

2. RADIOGRAPHIC MODALITIES

Conventional methods for evaluation of impacted teeth generally include intraoral periapical radiographs and panoramic radiographs, which are widely available in clinical set ups. They are usually adequate when the clinical question is limited to the presence, eruption status, and general orientation of the impacted teeth (2,4). While periapical radiographs demonstrate the relationship of impacted tooth to its neighbor, panoramic images help to visualize the relation of the impacted tooth to the alveolar crest, to the midline and surrounding vital structures such as the inferior alveolar canal. It also assists in decision making regarding whether the tooth needs extraction or a simple surgical exposure (2). Also in orthodontics, radiology plays a significant role in terms of evaluating impacted teeth in the light of patient's occlusion status, growth pattern, bone changes and pathology in adjacent tissues (2).

Being two-dimensional imaging modalities, the major limitation of these radiographs is that they fail to evaluate the buccolingual / buccopalatal relationship of the tooth (2,4,13). This is specifically important from a clinical point of view, as the risk of surgery is often related to the proximity of the tooth to the vital anatomical structures such as the mandibular canal, inferior alveolar nerve, maxillary sinus or the nasal cavity (3,13,14). Panoramic radiography has its limitations especially in cases of suspected root resorption of adjacent teeth and in cases of impacted maxillary canines, wherein three-dimensional imaging can be more informative (2).

Cone Beam Computed Tomography (CBCT) provides sagittal, coronal, axial views, along with cross-sectional and 3D reconstructed images, all of which improve localization of impacted teeth and their relationship to nerves, vessels, and surrounding bone (1,13,15).

Reviews consistently describe CBCT as an ideal alternative imaging modality when panoramic radiograph indicate approximation of the impacted third molar to the mandibular canal or when impacted canines are severely displaced, angled, or associated with suspected root resorption (2,3,13). CBCT-based classifications for maxillary canine impaction appear to offer more complete prediction of treatment difficulty than two-dimensional approaches alone (3).

Magnetic Resonance Imaging (MRI) is making progress as an adjunct for evaluation of impacted teeth as it can visualize the dentoalveolar complex without ionizing radiation. Available studies show that MRI can display impacted teeth, developing tooth buds, and their angulation, and adjacent anatomical structures (4,5). Flugge et al. also noted that several structures not visible on panoramic imaging were visible on the MRI (5). However, the reports are in their infancy since the study samples are small. CBCT is incomparable to MRI because of various reasons such as isotropic resolution of CBCT, which has not been achieved by MRI, and imaging may fail in patients with braces or motion artefact (5).

3. IMAGING IN TREATMENT PLANNING

Surgical management of an impacted tooth regarding whether an impacted tooth should be monitored, surgically exposed, orthodontically guided into position, or removed largely depends on the radiographic assessment (1,2,13). For teeth intended to be preserved, treatment success depends on accurate localization and realistic appraisal of eruption potential and treatment difficulty (1,3). For those teeth that require extraction, imaging helps define proximity to neurovascular structures and therefore helps to predict the risk of nerve injury, postoperative paresthesia, and operative difficulty (5,13,14).

For mandibular third molars, preoperative radiographic evaluation is particularly important because these teeth often lie close to the inferior alveolar nerve and mandibular canal (4,13). Conventional radiographs can suggest risk, but they do not adequately reveal the buccal or lingual course of the nerve, so further three-dimensional imaging is justified when specific warning signs are present (13). Better anatomical definition appears to reduce surgeon's uncertainty and procedure duration by clarifying the exact position of relevant structures before surgery (13).

For maxillary canines, radiology helps classify impaction pattern and estimate exposure difficulty (3). Palatal impaction is described as common, and complex positions near the maxillary sinus or nasal cavity increase the likelihood of procedural difficulty (2,3). When the canine–midline angle exceeds 30 degrees or adjacent root resorption is suspected, limited-field CBCT is recommended to improve localization while attempting dose control (2).

A broader theme across the literature is that impacted tooth management increasingly benefits from multidisciplinary planning rather than isolated surgical decision-making (1,2). Imaging significantly contributes not only to diagnosis but also to prognosis, communication among specialties, and evaluation of surrounding pathology such as cysts, tumors, inflammation, or root resorption (1,2).

4. RADIATION SAFETY AND EMERGING DIRECTIONS

The literature is unswerving that radiographic examination must follow justification and optimization principles (2,13). Advanced imaging should be reserved for medically justified situations, and the smallest field capable of answering clinical questions is preferred when CBCT is used (2). Although CBCT involves reduced radiation exposure to the patients as compared to other three-dimensional technologies such as Computed Tomography (CT), still CBCT is a modality involving a higher-dose than routine intraoral or panoramic imaging and hence cautions against overuse (4,13).

MRI is attractive because it is radiation-free, and dental MRI reviews suggest a clinically useful role when its indications and limitations are respected (4,5). Still, MRI for impacted teeth is not yet a standard replacement for CBCT because comparative accuracy data remains sparse, technical protocols vary, and artefacts can limit image quality (5). More broadly, oral cavity imaging research shows that CT and MRI are complementary across complex oral conditions, but image interpretation can be complicated by close mucosal apposition and metal artefacts (13).

Advancements in digital technologies may influence impacted-tooth imaging workflows in the future. Artificial intelligence is increasingly used in dentistry for diagnosis, decision support, treatment planning, and radiology-related applications, but it is still viewed as an adjunct tool rather than an alternative for clinicians' decisions (16). Reviews suggest AI could enhance interpretation of CBCT datasets in anatomically complex cases, although this remains an emerging rather than established application (15,17).

Other digital tools such as intraoral scanners increasingly support diagnostics and treatment planning, but the available evidence does not place them at the center of impacted tooth localization in the way panoramic imaging, CBCT, and MRI do (18).

5. CONCLUSION

Oral radiology is central to the treatment of impacted teeth because it defines tooth position, clarifies relationships to adjacent structures, estimates treatment difficulty, and helps reduce avoidable complications. The most consistent evidence supports a stepwise approach: begin with periapical or panoramic imaging when sufficient, use CBCT for justified complex cases where three-dimensional information changes management, and consider MRI as a promising radiation-free adjunct where available and technically feasible.

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