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MRI DIAGNOSIS OF BONE TUMORS: CONCEPTUAL APPROACH TO IMPROVE DIAGNOSTIC ACCURACY

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ANNOTATION

The history and current state of MRI diagnostics in bone tumors are characterized. The key participants in the diagnostic process are outlined, basic principles are formulated. Challenges in differentiating benign, intermediate, and malignant lesions are discussed, and approaches to improve diagnostic accuracy are proposed.

Keywords: MRI, bone tumors, diagnostic protocols, imaging standardization, tumor characterization

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МРТ ДИАГНОСТИКА ОПУХОЛЕЙ КОСТЕЙ: КОНЦЕПТУАЛЬНЫЙ ПОДХОД ДЛЯ ПОВЫШЕНИЯ ТОЧНОСТИ ДИАГНОСТИКИ

АННОТАЦИЯ

Охарактеризованы история и современное состояние МРТ диагностики опухолей костей. Перечислены ключевые участники процесса, сформулированы основные принципы. Обсуждаются проблемы дифференциальной диагностики доброкачественных, промежуточных и злокачественных опухолей, предлагаются пути повышения точности диагностики.

Ключевые слова: МРТ, опухоли костей, протокол диагностики, стандартизация изображений, характеристика опухолей

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SUYAK O'SMALARINI MRT TEKSHIRUVIDA ANIQLASH: DIAGNOSTIKA ANIQLIGINI OSHIRISH UCHUN KONTSEPTUAL YONDASHUV

ANNOTATSIYA

Suyak o'smalarini MRI yordamida diagnostika qilish tarixi va hozirgi holati tavsiflangan. Jarayonning asosiy ishtirokchilari va printsiplari sanab o'tilgan. Benign, o'rta va malign o'simalarning farqlanishidagi muammolar muhokama qilingan va diagnostik aniqlikni oshirish yo'llari ko'rsatib o'tilgan.

Kalit so'zlar: MRI, suyak o'smalari, diagnostika protokoli, tasvirni standartlashtirish, o'simta xususiyatlari

The diagnostic evaluation of bone tumors requires an integrated multimodality imaging strategy that encompasses conventional radiography (Roentgen), computed tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI). Each modality provides distinct and complementary information; however, their diagnostic value varies considerably depending on tumor location, composition, and biological behavior. Understanding the advantages and limitations of each imaging technique is essential for accurate lesion characterization, differential diagnosis, staging, and multidisciplinary treatment planning [1,3,7,9,11].

Roentgen (X-ray Radiography). Conventional X-ray remains the foundational first-line investigation for suspected bone tumors. It provides rapid, inexpensive, and widely available assessment of bone density, cortical integrity, periosteal reaction, matrix calcification, and overall lesion morphology. Characteristic mineralization patterns—such as osteoid, chondroid, or fibrous matrix—may offer crucial diagnostic clues [2,8,11,12,14].

However, despite its importance, X-ray lacks the ability to evaluate bone marrow involvement, intramedullary tumor extent, soft tissue invasion, and early destructive changes, which often remain radiographically occult. Therefore, radiographs function primarily as an initial screening tool, necessitating advanced imaging for comprehensive evaluation [5,7,12,13].

Computed Tomography (CT Scan). CT offers superior depiction of cortical bone destruction, mineralized tumor matrix, and complex anatomical regions such as the pelvis, clavicle, spine, and skull base. It is especially useful when assessing subtle calcifications, differentiating solid from mineralized components, and guiding percutaneous biopsies with high precision [4,6,7,8].

Despite these strengths, CT remains limited by inferior soft tissue contrast and exposure to ionizing radiation. It cannot reliably delineate marrow infiltration, neurovascular involvement, or soft tissue mass characteristics, making it less suitable for complete tumor staging. Nevertheless, CT remains indispensable in specific clinical situations, particularly in preoperative planning.

Ultrasound (US). Ultrasound plays a supplementary role in bone tumor assessment. It is helpful for evaluating superficial lesions, cystic vs. solid components, reactive soft tissue changes, tendon or bursa involvement, and real-time assessment of vascularity using Doppler imaging. Ultrasound is advantageous due to its safety, lack of radiation, and dynamic capability [1,3,5,7,8].

Yet, ultrasound cannot penetrate cortical bone, limiting its use to extraosseous and superficial soft tissue components only. It offers no information about intramedullary pathology. Therefore, while US is valuable as an adjunctive tool, it cannot function as a standalone modality in bone tumor evaluation.

Magnetic resonance imaging has become a cornerstone in the diagnosis of bone tumors due to its superior contrast resolution and ability to visualize both bone and soft tissue structures. MRI allows accurate characterization of tumor location, size, internal architecture, and relationship with surrounding tissues, aiding in differentiation between benign, intermediate, and malignant lesions [11,12,13,14].

A conceptual approach in MRI diagnostics involves standardized imaging protocols, structured reporting systems, and integration of clinical and laboratory findings to optimize diagnostic

accuracy and improve patient outcomes. This approach ensures systematic evaluation of lesions and facilitates multidisciplinary collaboration in bone tumor management.

Bone tumors are a heterogeneous group of lesions with a wide spectrum of biological behavior. MRI has become the method of choice for the evaluation of bone tumors because it provides excellent soft tissue contrast and the ability to visualize lesion extent in multiple planes. A conceptual approach in MRI diagnostics involves: Standardized imaging protocols (T1, T2, STIR, contrast-enhanced sequences). Structured reporting to ensure reproducibility and consistency. Integration of clinical, laboratory, and histopathological findings [3,4,5,12].

This approach allows for systematic evaluation, better differentiation of benign and malignant lesions, and supports multidisciplinary decision-making. Functional MRI techniques, including diffusion-weighted imaging (DWI) and dynamic contrast-enhanced (DCE) imaging, further enhance characterization by offering insights into tumor cellularity and vascularity. Benign tumors: well-defined margins, homogeneous signals. Intermediate tumors: mixed signal, mild cortical involvement. Malignant tumors: irregular margins, heterogeneous signal, soft tissue extension. Challenges: Differentiating intermediate and malignant lesions, small lesion size, atypical signal patterns [1,5,7,9,11].

DISCUSSION. MRI provides unparalleled visualization of bone tumors. Implementing standardized protocols and structured reporting enhances diagnostic accuracy and reduces inter-observer variability. Functional sequences, such as DWI and dynamic contrast-enhanced MRI, can further aid in identifying aggressive lesions. Limitations include single-center retrospective design. Future studies should explore AI-assisted imaging analysis and multicenter validation.

CONCLUSION. A conceptual approach in MRI diagnostics of bone tumors improves accuracy, aids clinical decision-making, and supports multidisciplinary management. Adoption of standardized protocols can optimize patient outcomes.

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