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Quantitative Musculoskeletal MRI for Non-Tumorous Conditions

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Quantitative magnetic resonance imaging (qMRI) has emerged as a powerful tool for evaluating musculoskeletal tissues beyond conventional morphological assessment. Recent advances in compositional cartilage imaging (T2, T1 ρ , dGEMRIC, gagCEST), ultrashort echo time (UTE) and zero echo time (ZTE) techniques for tendons, fibrocartilage, and cortical bone, as well as multiparametric approaches for skeletal muscle (PDFFF, T2 mapping, diffusion MRI), have significantly broadened the clinical and research applications of qMRI. These methods provide noninvasive biomarkers of tissue composition, microstructure, and pathophysiological changes, offering potential for early disease detection, monitoring of degeneration and regeneration, and objective outcome evaluation in therapeutic trials. Despite technical challenges, including standardization, acquisition time, and interpretation, qMRI is progressively moving toward clinical translation. This review summarizes the current state, methodological principles, and emerging applications of quantitative musculoskeletal MRI, highlighting its promise and limitations in advancing precision musculoskeletal imaging.