Update on imaging in rheumatology – recent advances

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Abstract

Imaging plays a vital role in the diagnosis and management of rheumatological disorders. Traditionally, plain film radiography was widely used in arthropathies to assess periarticular bony changes; these often reflect established changes in the late stage of disease and thus have limited value in early diagnosis and disease monitoring. Magnetic resonance imaging (MRI) has become an important imaging modality in rheumatological disorders because it can assess both morphological and functional changes. It plays a substantial role in early diagnosis, monitoring of disease evolution, assessment of treatment responses and prognostication. More recently, advances in hardware and novel imaging sequences have aided the development of new MRI techniques: whole-body MRI, for example, is gaining in popularity and allows an assessment of overall inflammatory status in arthritis. Quantitative MRI shows promise in allowing more objective evaluation and standardization of imaging-based assessment of inflammatory arthritis. This article also discusses other emerging imaging techniques. These include high-resolution peripheral quantitative computed tomography in early detection and monitoring of periarticular bone damage, fluorescence optical imaging in visualizing active inflammation, and molecular imaging in investigating pathogenesis and disease evaluation on a cellular level.

Keywords Arthritides; arthritis; arthropathy; imaging; inflammatory; magnetic resonance imaging; positron emission tomography; rheumatoid; rheumatological

Key points

- Structural bony changes seen on radiographs reflect late disease, and thus have a limited role in early diagnosis and disease monitoring
- Magnetic resonance imaging (MRI) is highly sensitive for detecting early bony changes and synovial inflammation, and is becoming more routinely used for early diagnosis, disease/treatment monitoring and prognostication of arthropathies
- Novel magnetic resonance techniques provide new avenues for disease evaluation: whole-body MRI facilitates detection of inflammation at multiple sites; diffusion-weighted imaging, dynamic contrast enhancement and chemical-shift-encoded MRI provide quantitative and objective assessment of periarticular damage and can aid in standardization and automation
- Other developments include fluorescence optical imaging, which provides a quick and non-invasive overview of active inflammation of the extremities, and receptor-specific molecular imaging, which shows potential for monitoring of pathogenesis, disease evolution and treatment selection/response

Introduction

Plain radiography has in the past been the primary imaging tool for investigating arthropathies. Radiographic features of the various types of arthritis have been extensively described in the literature and previously in this journal. However, structural bony changes, such as sclerosis and erosions, seen on radiographs, occur late in the course of disease, and early changes are not apparent. The sensitivity of plain films is low, and disease activity cannot be adequately assessed. Pelvic and lumbar spine radiography incurs a relatively high dose of ionizing radiation; for example, the dose from an anteroposterior radiograph of the pelvis is 35 times that from a chest X-ray. It should therefore be avoided where possible, particularly in children and adolescents. Magnetic resonance imaging (MRI) and ultrasonography are being increasingly used to aid early diagnosis of arthropathies, and this facilitates early treatment that may prevent progression to irreversible structural damage.

Here we describe recent advances in the imaging of rheumatological diseases. For a more in-depth review of the role of ultrasound, the interested reader is referred to the dedicated ultrasound chapter (10.1016/j.mpmed.2017.12.010) in this publication.

Magnetic resonance imaging

MRI has emerged as the most sensitive imaging modality for detecting arthritis and discriminating between acute and chronic inflammation. In recent years, substantial technical advances have been made in software and hardware, such as phased-array coils, higher performance gradients, parallel imaging and advanced post-processing techniques. This has led to reduced scan times and improved image quality.

Other advances include isotropic three-dimensional (3D) imaging techniques, which reduce partial volume artefacts and allow reformatting in multiple planes for improved visualization of anatomy and pathology. High-field strength systems (e.g. 3T MRI) are increasingly used in clinical practice, providing better spatial resolution and signal-to-noise ratio.

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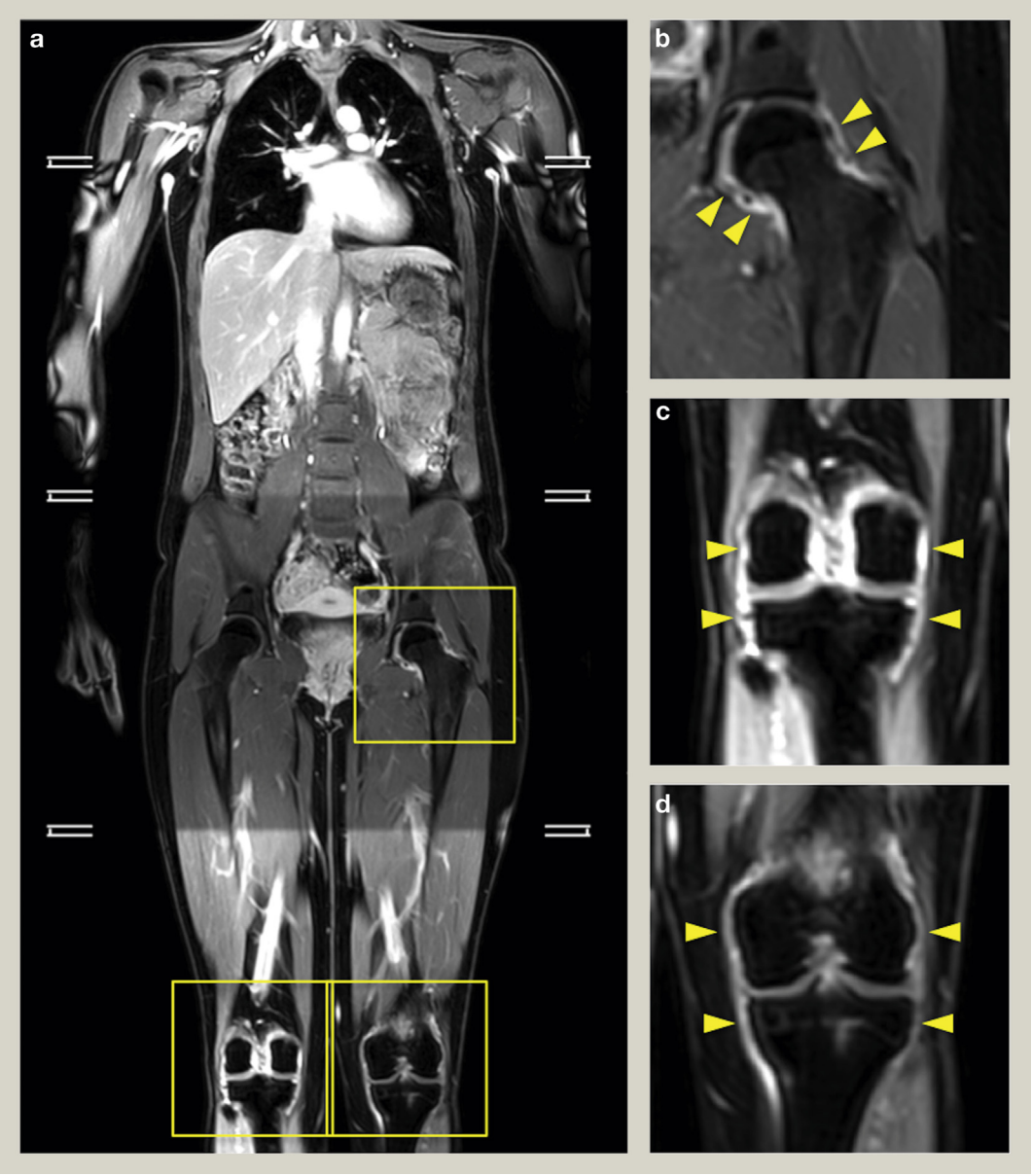

Figure 1 Whole-body MRI (WB-MRI) of a 22-year-old patient with polyarticular juvenile inflammatory arthritis. WB-MRI can image multiple joints, facilitating assessment of the distribution and severity of joint inflammation. (**a**) Large field of view image showing enhancing active synovitis in the left hip and right knee. Note the asymmetry of the hips, with lack of synovial enhancement of the right hip. Magnified views of the diseased left hip (**b**) and right knee (**c**) (compare with a normal left knee, seen in (**d**)), with arrowheads depicting the enhancing synovium.

Applications of morphological MRI and common findings

Conventionally, morphological and contrast-enhanced MRI are used to assess inflammatory arthritis. In general, short tau inversion recovery (STIR) and contrast-enhanced T1-weighted images are useful for assessing active inflammation.

In rheumatoid arthritis, the diseased joints show proliferative synovitis on MRI. This inflammation leads to bone erosions, which in the acute phase demonstrate loss of cortical definition and presence of subcortical bone marrow oedema (osteitis). These are seen as high signal on STIR (which is fluid-sensitive) and contrast-enhanced images. Mature erosions show sharply marginated areas of trabecular bone loss with cortical defects. Tenosynovitis, a common finding, is seen as synovial sheath thickening with marked enhancement on post-contrast images.

In axial and peripheral spondyloarthropathies, sacroiliitis is a common feature; it is seen on MRI as subchondral bone marrow oedema, synovitis, capsulitis and enthesitis. In the new Assessment of Spondyloarthritis International Society criteria for axial spondyloarthritis,[1] the presence of subchondral bone marrow oedema is mandatory for the diagnosis of acute sacroiliitis. In chronic sacroiliitis, periarticular fat metaplasia, sclerosis and erosions are seen, followed by ankylosis in some patients. Active spondylitis is seen as facet and costovertebral joint synovitis, enthesitis of spinal ligaments and corner inflammatory lesions resulting from bone marrow oedema of the vertebral entheses.

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