MRI of gout: a pictorial review

There has been renewed clinical interest in gout secondary to the recent advances in the understanding of its cellular inflammatory mediators, which have led to new and emerging therapies for treatment. The role of advanced imaging in gout is currently evolving to compliment modern clinical challenges in the treatment of gout. Furthermore, the clinical diagnosis of gout remains potentially challenging, especially in the setting of an atypical presentation and advanced imaging is often utilized in these circumstances. This article seeks to provide a timely review of the magnetic resonance features of chronic tophaceous gout in a pictorial exhibition, as well as provide a future perspective of the utilization of advanced imaging: computed tomography, MRI and ultrasound in the clinical management of gout.

KEYWORDS: advanced imaging ■ gout ■ MRI

Calvin L Barnes & Clyde A Helms*

Duke University Medical Center, Department of Radiology, Division of Musculoskeletal Radiology, Durham NC, 27710, USA
**Author for correspondence: Tel.: +1 919 684 7453 clyde.helms@duke.edu*

Gout is a systemic, inflammatory arthritis caused by deposition of monosodium urate (MSU) crystals within synovial or periarticular tissue. Currently, it is estimated to affect 6.1 million Americans [1,2]. The acute phase of gout manifests clinically as a monoarticular inflammatory arthritis, and can mimic a septic joint. Chronic gout is characterized by the formation of tophi, both intraosseous and periarticular. If left untreated, chronic tophaceous gout will lead to destructive arthropathy as well as other morbidities.

The classic radiographic findings in gout are well-defined, 'punched-out' periarticular erosions with overhanging edges, with relative preservation of joint space and osseous mineralization and have been well described in the literature [3]. However, these findings usually manifest late in the disease [4]. Radiographs are often utilized in the initial diagnosis to exclude other causes of joint pain. The evaluation of gout remains primarily a clinical and laboratory diagnosis. The gold standard in the diagnosis of gout is aspiration of the joint, with detection of negatively birefringent MSU crystals under polarizing microscopy [5,6]. However, this is not routinely performed in clinical practice [7].

This article will provide a pictorial review of the various magnetic resonance (MR) appearances of tophaceous gout. The findings on MR of gouty arthropathy include synovitis or synovial pannus, tophi, erosions and reactive bone marrow change. MR has been shown to be much more sensitive than conventional radiographs in the detection of erosions [8]. MR also provides excellent soft tissue contrast to detect complications of MSU deposition, such as bursitis, intra-articular tophi, tenosynovits and tendon ruptures [9–11]. MR characteristics of gouty tophus have been described as near isointense to skeletal muscle on T_1-weighted sequences, and heterogeneous in signal on T_2-weighted sequences [12]. Additionally, gouty tophus do not have a characteristic pattern of enhancement [13]. Most of the articles in the literature have focused on the appearance of chronic, tophaceous gout. However, in addition, initial acute gout flares have been shown to demonstrate synovitis, reactive bone marrow edema and erosions [14]. Unfortunately, the imaging characteristics of tophi, as well as other MR findings in gout lack specificity. Other inflammatory arthritides, as well as infectious arthritis can have a similar appearance and remain diagnostic considerations based solely on the MR appearance. Specifically, gouty tophi are grouped in the MR differential diagnosis of intra-articular masses, of which the most common include the synovial pannus of rheumatoid arthritis, amyloid arthropathy and chronic granulomatous infections, such as tuberculosis [15]. Occasionally, if the tophi are heavily calcified, they can also simulate pigmented villonodular synovitis on MR as the calcification demonstrates similar signal as hemosiderin [16].

In the following pictorial review, Figures 1–5 review the MR appearance of tophaceous gout, as well as demonstrate some of the associated soft tissue complications, beginning in the peripheral appendicular skeleton, and advancing proximally. Accompanying radiographs also demonstrate the marked, increased sensitivity of

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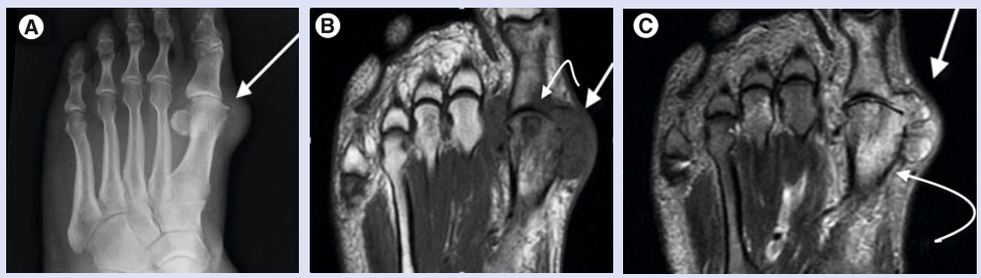

Figure 1. Tophaceous gout in the great toe. (A) One of the classic locations for gout is at the metatarsophalangeal joint of the great toe. This radiograph of the right foot with gout demonstrates a periarticular soft tissue mass, with adjacent erosions around the metatarsophalangeal joint (straight arrow). **(B)** Coronal T_1-weighted MRI of the same foot demonstrates a hypointense periarticular mass medial to the metatarsophalangeal joint, compatible with a tophus (straight arrow). The erosions at the head of the first metatarsal and base of the proximal phalanx are much more apparent (curved arrow). **(C)** Coronal T_2-weighted MRIs of the foot demonstrates that the periarticular mass is hyperintense on the T_2-weighted sequence (straight arrow). The T_2 weighting also highlights the reactive bone marrow edema (curved arrow).

MRI. Additionally, Figure 6 and Figure 7, which are cases of amyloid arthropathy and rheumatoid arthritis in the shoulder respectively, were selected to demonstrate the limitations of MR in the initial diagnosis of gout due to relative lack of specificity in the MR findings.

Future perspective

There has been recent interest in utilizing advanced imaging to quantify tophus burden as a marker of response to therapy. Schumacher *et al.* reported a multicenter study evaluating the intra- and inter-reader variability in calculating tophus volumes utilizing MR [17]. They found that there was excellent intrareader reproducibility, with no statistical difference in volume measurements between two visits. They did find a statistical difference in the inter-reader variability, although the actual difference in the volume measurement between readers was small. This study was limited by inherent artifacts in some of the MR protocols and there is a paucity of other studies to corroborate their results.

Dual-energy computed tomography (CT) is a relatively recent technology that allows acquisition of data simultaneously at two different energy levels (kilovolts). Given the different chemical composition of calcium and MSU deposits, their attenuation properties at the two different energy levels allow them to be distinguished from each other. Moreover, CT post-processing techniques, such as color mapping, 3D surface rendering and volumetric analysis provide accurate and readily interpretable images, and this technology may become very useful in both initial diagnosis in atypical clinical

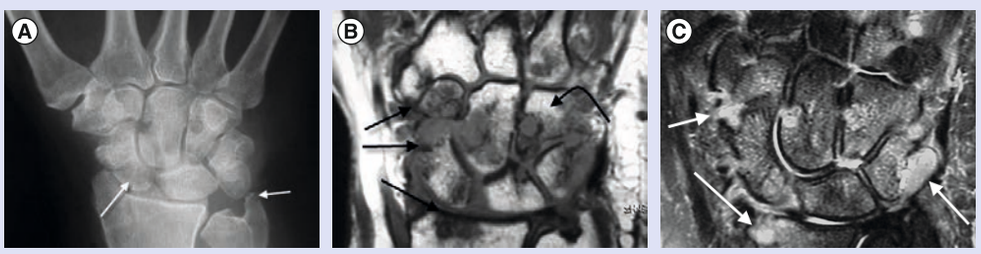

Figure 2. Tophaceous gout in the wrist. (A) Typical radiographic findings in gout in the wrist. There are subtle lucencies in the carpus and irregularity of the ulnar styloid consistent with erosions (arrows). The joint spaces and osseous mineralization are relatively preserved. **(B)** T_1-weighted coronal MRI of the same wrist demonstrates much more extensive carpal erosions, associated with hypointense intra-articular masses, compatible with tophi. When compared to the radiograph, there is far superior characterization of the extent of bony involvement, as evidenced by the erosion and destruction of the scaphoid, trapezoid, hamate and distal radius for example (arrows). Evaluation of the radiograph alone would have severely underestimated the degree of gouty involvement of the wrist in this patient. **(C)** T_2-weighted coronal MRI of the wrist demonstrates that the tophi are primarily hyperintense in signal, with some foci of intermediate signal also observed (arrows). Diffuse reactive bone marrow edema is also seen. Tophi can be variable in signal on T_2-weighted sequences, as will be demonstrated in subsequent figures.

presentations as well as assessing response to various therapies [18–20]. The advantages over MR include cost and time, although one drawback is ionizing radiation. Additionally, dual-energy CT is highly specific for gout and may obviate the need for joint aspiration [18].

Another method of assessing tophi includes ultrasound [21]. Superficial structures, such as the olecrenon bursa and prepatellar bursa as well as peripheral joints within the hand and feet can be easily accessed and examined with a high-frequency transducer. Ultrasound has been shown to be capable of monitoring treatment response in tophaceous gout [22]. Limitations of ultrasound include an inherent operator dependence to reliably reproduce images and can be time intensive, pending patient body habitus. Ultrasound has also been demonstrated to be less sensitive than MR, especially in the assessment of subclinical disease or osseous erosions [8]. However, a recent review of the literature regarding all current methods of tophus assessment did find that physical measurement techniques and ultrasound most closely meet the criteria of the Outcomes Measure in Rheumatology [23].

The initial diagnosis of gout will most likely remain a clinical- and laboratory-based diagnosis in the perceivable future. Although MR is very sensitive to detection of disease, it lacks specificity and is not cost effective for routine evaluation. MR does and will continue to have a role in the evaluation of patients with atypical presentations, or in patients with clinical suspicion of internal derangement. There have been recent advances in the understanding of the underlying inflammatory pathways in gout, with IL-1 being implicated as the crucial mediator of inflammation [24]. As a result, new drugs targeting IL-1 activation are currently being heavily investigated [25]. It is very likely that as the pharmacologic treatment of chronic rheumatologic conditions, such as gout, become more sophisticated, the role of MR, as well as CT and ultrasound will expand to be utilized in the monitoring of disease response.

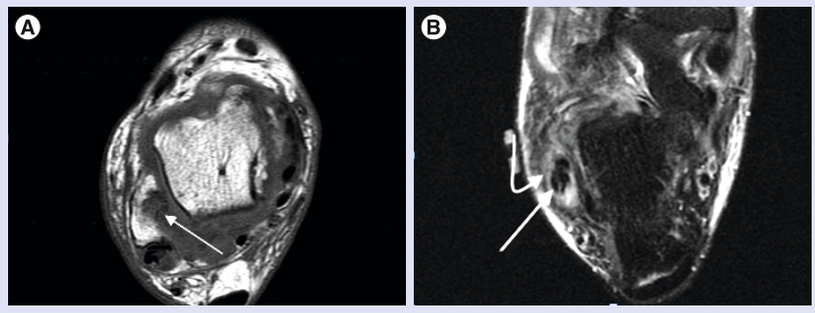

Figure 3. Tophaceous gout in the ankle, with tendon involvement.
(A) T_1-weighted axial magnetic resonance of the ankle in a man presenting with ankle pain demonstrating circumferential low signal mass around the joint compatible with synovitis/pannus. There is a tophus with erosion seen in the distal fibula (arrow). **(B)** T_2-weighted axial MRI of the patient's foot distal to the ankle joint demonstrates an intermediate signal mass within the peroneal tendon sheath, which was proven surgically to be gouty infiltration with tenosynovitis (curved arrow). Additionally, there is a split tear of the peroneus longus tendon, represented by the vertical band of high T_2 signal within the tendon (straight arrow).

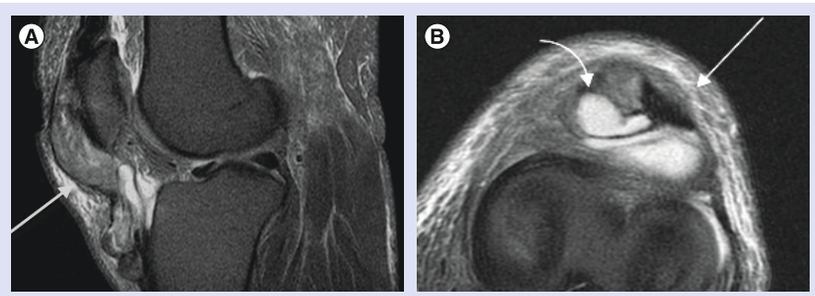

Figure 4. Tophaceous gout in the knee, with tendon involvement.
(A) Sagittal T_2-weighted magnetic resonance of the left knee, demonstrating a T_2-intermediate signal mass in the patellar tendon, representing an isolated gouty tophus (arrow). Notice the lack of a joint effusion. There is a partial tear of the distal patellar tendon, see **(B)**. **(B)** T_2-weighted axial MRI of the knee just distal to the tophus demonstrates the thickened, intermediate in signal patellar tendon with an intratendinous fluid collection (curved arrow), compatible with a partial tear. For comparison, the more normal appearing patellar tendon is seen laterally (straight arrow). Tendons normally appear low in signal, and homogenous on both T_1- and T_2-weighted sequences.

Executive summary

MRI of gout

- Magnetic resonance (MR) findings in gout include erosions, reactive bone marrow edema, soft tissue masses/tophi and synovitis/pannus.
- MR is very useful in characterization of soft tissue complications of gout with internal derangement of joints, such as tenosynovitis or frank tendon rupture, as well as spinal complications, particularly C1–C2 synovial disease.
- Unfortunately, while MRI is highly sensitive in the detection of gout, the MR features are nonspecific and can be seen in other inflammatory arthritis, such as rheumatoid, amyloid arthropathy, as well as in infectious arthritis. The cost of MR also limits its use as a screening tool.

Perspectives

- MR, computed tomography and ultrasound have all demonstrated potential utility in monitoring treatment response.
- Dual-energy computed tomography is a promising, emerging technology that is highly sensitive for gout.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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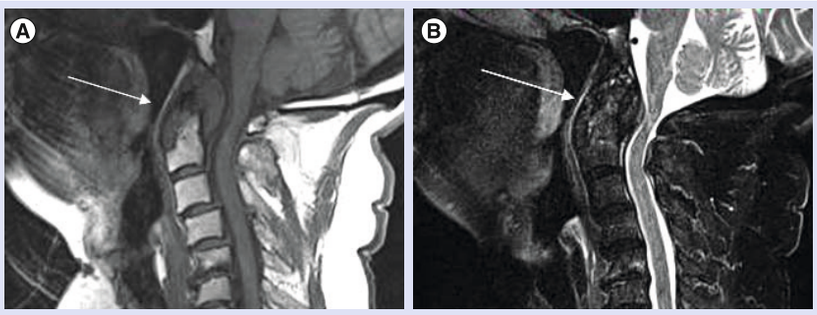

Figure 5. Tophaceous gout in the cervical spine. (A) The C1–C2 articulation is a synovial joint, and can be an anatomic region where pannus/tophi can occur in gout and other crystalline and inflammatory arthritides. On this sagittal T_1-weighted magnetic resonance of the cervical spine, a gouty tophis is seen as a hypointense mass eroding the dens (arrow). **(B)** On this sagittal T_2-weighed MRI of the cervical spine, the tophus is hypointense, reflecting the variability of the T_2 signal in gouty tophi. This mass is seen effacing the ventral epidural space, and impinging the spinal cord. This necessitated a craniocervical decompression in this patient.

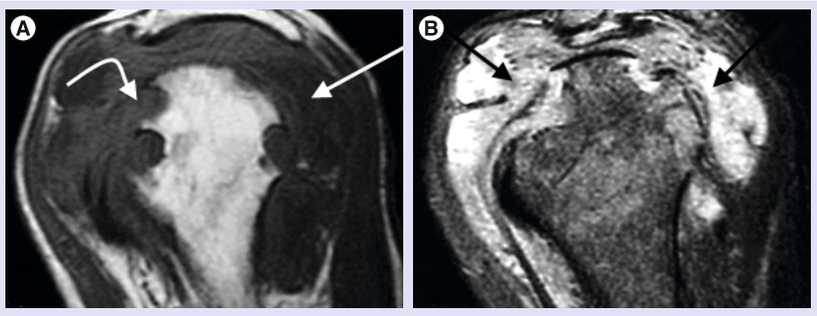

Figure 6. Amyloidosis in the shoulder. (A) Oblique sagittal T_1-weighted magnetic resonance of a shoulder in a patient demonstrates diffuse hypointense soft tissue within the glenohumeral joint (straight arrow). There are also periarticular erosions seen on the humeral head (curved arrow). **(B)** Oblique sagittal T_2-weighted MRIs of the same shoulder demonstrate that the synovial soft tissue mass is heterogeneous in signal with areas of high and intermediate signal (arrows). This process was secondary to amyloidosis. These magnetic resonance features are indistinguishable from gout. Other inflammatory conditions such as rheumatoid (see Figure 7) as well as an infectious arthritis could have a similar appearance.

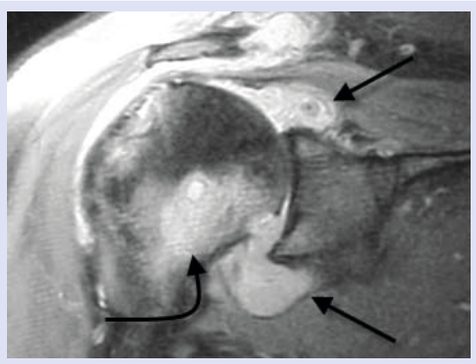

Figure 7. Rheumatoid arthritis in the shoulder. Coronal oblique sagittal T_2-weighted images of a shoulder demonstrate diffuse synovial soft tissue that is intermediate in signal intensity (straight arrows). There is also an erosion with associated bone marrow edema seen in the medial humeral head (curved arrow). These findings were secondary to rheumatoid arthritis, with the synovial soft tissue proliferation representing synovitis. Again, a similar appearance could be seen in gout or other inflammatory or infectious arthritis.

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