MR Imaging Manifestations of Gout: A Crystal Clear Review

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Learning objectives

1. A brief discussion of the epidemiology, pathophysiology and clinical presentation of gout

2. A detailed review of the MR imaging findings of gout with radiographic correlation when appropriate

3. A review of the differential diagnostic considerations with regards to MRI findings in gout

Background

Epidemiology

- The Third National Health and Nutrition Examination Survey (NHANES III) estimates the prevalence of gout in the US population to be 5.1 million between 1988 and 1994

- Data from a US managed care claims database revealed an increase in gout prevalence from 2.9 cases per 1,000 persons in 1990 to 5.2 cases per 1,000 persons in 1999

- The NHANES III data show that gout affected more than 3 million men aged 40 years or older, and 1.7 million women aged 40 years or older, from 1988 to 1994

- Estimated prevalence of gout among men aged 40 years or older makes gout more common than rheumatoid arthritis and the most common form of inflammatory arthritis in adult men

- The incidence of gout is also increasing


- They found the age- and sex-adjusted annual incidence of gout to be higher in 1995-1996 (62.3 cases per 100,000 persons) than in 1977-1978 (45.0 cases per 100,000 persons)
Pathophysiology

- Excessive uric acid accumulation contributes to hyperuricemia (defined as an elevated serum uric acid (sUA) level above 7 mg/dl in men and above 6 mg/dl in women. This is considered to be the principle cause of gouty arthritis

- Definition of gouty arthritis: The acute and chronic clinical manifestations caused by the deposition of monosodium urate crystals in articular and extra-articular tissues

- The greater sUA levels exceed their plasma saturation point, the greater the likelihood of acute gouty arthritic attacks

- Serum uric acid levels in excess of 10 mg/dl promote formation of tophaceous deposits that may present as late as 10 years from the initial gouty attack

Clinical Presentation

- Classically acute gouty arthritis flares includes severe localized pain, joint inflammation, warmth, and redness, usually of the 1st metatarsophalangeal joint

- Clinical presentation can differ in elderly patients and may be confused with rheumatoid arthritis due to more diffuse symptoms at presentation

- According to the American College of Rheumatology patients must have monosodium urate crystals in the synovial fluid and/or tophi confirmed with crystal examination

- In addition, patients must have at least six of the following findings:
  
  • Asymmetric swelling within a joint on a radiograph
  • First metatarsophalangeal joint is tender or swollen
  • Hyperuricemia
  • Maximal inflammation developed within 1 day
  • Monoarthritis attack
  • More than one acute arthritis attack
  • Redness observed over joints
  • Subcortical cysts without erosions on a radiograph
  • Suspected tophi
  • Synovial fluid culture negative for organisms during an acute attack
• Unilateral first metatarsophalangeal joint attack
• Unilateral tarsal joint attack

- MRI is becoming increasingly important in the clinical management of gout.

- Many patients with gout demonstrate normal plain film radiographs

- However, they may have occult destructive arthropathy that is only detected by advanced imaging such as MRI, with approximately half of these patients demonstrating bone erosions and synovial pannus

**In this presentation we review various MR imaging manifestations of gout, specifically:**

- Tophi
  - Soft tissue tophi versus calcified tophi
  - Intraosseous versus extra-articular versus intra-articular tophi

- Erosions

- Synovitis

- Tenosynovitis

- Bursitis

- Effusions

**Imaging findings OR Procedure details**

**Tophi:**

- A sequelae of long standing gout

- Manifested by the deposition of monosodium urate crystals in soft tissues and bone
Acute cases of gouty tophi have been reported, sometimes making it difficult to differentiate from tumor.

**MRI manifestations:**
- Low to intermediate signal on T1 weighted images,
- Variable signal on T2-weighting, depending on calcium concentration within tophus
- Typically demonstrate heterogeneous enhancement on post-gadolinium imaging, depending on degree of granulation tissue present

- The tophi may be predominantly intra-articular, extra-articular, or intraosseous in nature

- It may also be calcified versus soft tissue in nature

**Types of tophi**
- **Intra-articular tophi**
  1. May develop earlier than other types of tophi as crystal shedding from cartilage has been presumed to precipitate an acute gouty attack
- **Extra-articular tophi**
  1. Common locations include in the olecranon bursa, helix and antihelix of ears, ulnar surface of forearm, and Achilles tendon
  2. Can present in the hand as nerve entrapment, dermatitis, tophaceous infiltration of the tendon, joint contractures, skin ulceration, a draining sinus, or tenosynovitis
  3. **Intra-articular tophi**
  1. Tend to be subcortical as the disease progresses
  2. Typically metaphyseal and periosteal in location, commonly
involving the long bones

3. Lead to expansion and cystic changes occasionally with punctate calcifications

4. May mimic enchondroma or infarcts if calcified
   - Calcified tophi

1. Calcification of tophus is less common than soft tissue tophus

2. May reflect an underlying abnormality of calcium metabolism

3. Typically seen in the periphery of the tophus initially

4. Ossification is uncommon
   - Soft Tissue Tophus

1. Comprise majority of cases of tophi

2. Rarely occur in the absence of articular disease

- Figures 1 through 16 demonstrate the various types of tophi discussed above

**Erosions:**

- Pathogenesis is thought to be due to osteoclastogenesis indirectly related to monosodium urate deposition

- Frequently visualized at the medial and dorsal aspect of the 1st metatarsophalangeal joint although any joint may be involved
- Hallux valgus deformity is often seen

- Hindfoot can also be involved
  - Calcaneal erosions not uncommon
  - Associated with retrocalcaneal bursitis and Achilles tendon pathology

- MRI much more sensitive than radiographs for detecting early erosions

- Figures 17 through 21 provide examples of erosions

**Synovitis**

- As previously described, a period of hyperuricemia leads to monosodium urate deposition. This leads to synovial irritation and inflammation (i.e. synovitis)

- Synovial fluid analysis in patients with gout demonstrates monosodium urate crystal laden macrophages, confirming link between gout and urate deposition

- Like erosions, MRI is exquisitely sensitive for detecting underlying synovitis, seen in approximately 50% of patients who demonstrated normal plain film radiographs

- Figures 22 through 25 demonstrate examples of synovitis

**Tenosynovitis**

- Can mimic an infectious tenosynovitis
  - Has been mistaken for tuberculous tenosynovitis

- Literature review demonstrates a number of cases of gout related tenosynovitis
  - Typically involve the hand and wrist
  - Has been associated with carpal tunnel syndrome secondary to entrapment neuropathy of the median nerve

- More commonly, tenosynovitis in patients with gout is secondary or reactive in nature rather than a primary manifestation of disease
- Figures 26 through 30 demonstrate examples of tenosynovitis

**Bursitis:**

- As with tenosynovitis, bursitis can mimic an infectious etiology

- Olecranon bursa and prepatellar bursa most commonly involved

- Retrocalcaneal bursitis is also seen, commonly associated with calcaneal erosions and Achilles tendon pathology

- Rare locations such as the pes anserine bursa have also been reported

- **Figure 31 shows an example of bursitis in a patient with gout**

**Effusions:**

- Earliest radiologic sign of gout is a nonspecific joint effusion and periarticular swelling

- Secondary to an inflammatory reaction elicited by the deposition of urate crystals in the synovial membrane and articular cartilage

- **Figures 32 and 33 demonstrate case examples of effusions in patients with gout**

**Differential Diagnosis:**

- Calcium pyrophosphate deposition disease (CPPD)
  - Can mimic gout clinically
  - Differentiated by presence of chondrocalcinosis and absence of associated soft tissue mass

- Rheumatoid Arthritis
  - Typically a symmetric polyarticular disease
• Absence of sclerosis at the margins of erosions as is often seen in gout

- Septic arthritis
  • Fluid aspiration analysis is key
  • Gout manifests with needle shaped crystals and negative birefringence
  • May be difficult to distinguish from gout by radiographs or MRI. Therefore clinical history is key

- Psoriatic arthritis
  • Often demonstrates sacroiliac joint involvement, not seen in gout
  • May demonstrate paravertebral ossification

- Pigmented Villous Nodular Synovitis (PVNS)
  • MRI findings may mimic tophi on MRI, however PNVS may demonstrate blooming on gradient echo sequences

**A Look to the Future**

- Growing interest in ultrasound as valuable modality in gout management secondary to:
  • Lack of radiation
  • Relatively low cost compared with MRI and CT
  • Dynamic assessment
  • Interventional capabilities for gold-standard diagnostic procedures including synovial fluid and tophi aspiration

- Dual Energy CT
  • Has been shown to confirm gout with high accuracy by detecting monosodium urate crystals
  • Can detect gout in the preclinical stage allowing for treatment prior to bony destruction and irreversible damage
  • May prove beneficial as a tool to monitor response to therapy by assessing volumetric monosodium urate burden

**Images for this section:**
**Fig. 1**

*T1 weighted axial images* demonstrate a low signal intensity soft tissue mass adjacent to the first metatarsal head. *T2 weighted fat saturated images* demonstrate a heterogeneous, but slightly hyperintense appearance to this soft tissue tophus. *T1 fat saturated post contrast coronal images* reveal mild enhancement.

**Fig. 2**

*T1 weighted axial images* demonstrate another example a low signal intensity soft tissue mass adjacent to the first metatarsal head, compatible with a soft tissue tophus. Note extensive erosive changes involving the adjacent metatarsal head. *T1 fat saturated post contrast coronal images* demonstrate heterogeneous, predominantly peripheral enhancement of this tophus.
As seen in the previous examples, soft tissue tophi tend to manifest as low signal soft tissue masses on T1 weighted sequences. **T2 weighted fat saturated images** demonstrate a heterogeneous, but more hyperintense appearance to the tophus compared to the previous examples. Variable enhancement on T2 weighted sequences is typical. **Axial T1 weighted fat saturated sequence** demonstrates mild hyperintense signal.

Fig. 3

Frontal and oblique radiographs of the foot demonstrate amorphous calcification next to the first metatarsal head. In a patient with gout, calcified soft tissue tophus must be considered.

Fig. 4
**Fig. 5**

T1 axial and T2 coronal fat saturated weighted sequences of the same patient demonstrates a tophus with erosion of the first metatarsal head. The calcification noted on prior radiograph is difficult to appreciate by MRI denoting the importance of radiographic correlation to assess for calcified tophi.

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**Fig. 12**

As one can see, the elbow is a relatively common extra-articular manifestation of tophi in patients with gout. This example demonstrates a characteristic tophus in the olecranon bursa. T1 hypointense and T2 heterogeneously hyperintense signal within the tophus is seen.
Tophi (Extraarticular)

The extensor mechanism is not an uncommon extra-articular manifestation of gouty tophi. In this case there is a tophus centered within the mid to distal patellar tendon extending to the adjacent soft tissues.

As in prior examples there is T1 hypointense and T2 heterogeneously hyperintense signal. T1 fat saturated pre and post contrast images confirm enhancement of the tophus.

Fig. 14

Tophi (Intraosseous)

T1 weighted images demonstrate a typical low signal intensity appearance to a tophus. However, note the intraosseous appearance to this lesion within the first proximal phalanx. The tophus demonstrates hyperintense T1 fat saturated and T2 fat saturated signal.

Fig. 8
**Fig. 7**

*T1 and T2 fat saturated* sagittal images demonstrate coarse calcification associated with a tophus within and adjacent to the patellar tendon. *T1 fat saturated post contrast* images reveal enhancement surrounding the calcification.

**Fig. 9**

*Sagittal, axial and coronal T1 fat saturated post contrast* images of the same patient demonstrate heterogeneous enhancement of this intraosseous tophus.
Axial T1 and coronal T2 fat saturated images of the foot demonstrate a soft tissue tophus at the second metatarsophalangeal joint. Notice that the tophus is intra-articular in location, surrounded by the metatarsophalangeal collateral ligaments.

Extraarticular manifestations of gout can also be seen in the ankle. This case demonstrates a T1 hypointense, T2 hyperintense tophus posterior to the Achilles tendon. Note the thickened appearance to the Achilles tendon which may also represent intratendinous extension of this tophus.
Fig. 11

A similar case demonstrates an extra-articular tophus posterior to the triceps tendon. MRI characteristics are similar to prior examples, with T1 isointense, variable T2 intensity (in this case isointense to muscle), and heterogeneous post contrast enhancement.

Fig. 6

Lateral radiograph of the knee demonstrates large soft tissue calcifications in the expected location of the patellar tendon in this patient with gout.
**Tophi (Intraarticular)**

Axial T1 fat saturated pre and post contrast images demonstrate heterogeneous enhancement of this intra-articular tophus. Note the associated second metatarsal head erosion.

**Fig. 16**

**Tophi (Extraarticular)**

T1 axial, T1 sagittal, T2 fat saturated axial, and T2 fat saturated sagittal images of the elbow demonstrate a T1 hypointense, T2 hyperintense tophus within and adjacent to the triceps tendon. Note extension to the olecranon process where there are erosive changes.

**Fig. 10**
Fig. 26

T2 weighted fat saturated axial image through the ankle demonstrates fluid surrounding the posterior tibial tendon compatible with tenosynovitis.

Fig. 27

A similar case demonstrating fluid encircling the posterior tibial tendon on axial and sagittal T2 fat saturated sequences. This is compatible with tenosynovitis.
Additional T2 fat saturated sequences of the same patient also demonstrate extensive fluid encircling both the *flexor digitorum longus* and *flexor hallucis longus* tendons at the myotendinous junction consistent with tenosynovitis.

Fig. 28

T2 fat saturated axial, sagittal and coronal demonstrate massive fluid circumferentially surrounding the *extensor hallucis brevis* tendon with associated linear low signal bands of fibrosis. These constellation of findings are consistent with severe stenosing tenosynovitis.

Fig. 29
**Tenosynovitis**

Axial and sagittal T1 fat saturated post contrast images of the foot demonstrate circumferential fluid and enhancement surrounding the second flexor digitorum longus and brevis tendons indicating tenosynovitis.

Fig. 30

**Bursitis**

Axial and coronal T2 weighted fat saturated images of the foot demonstrate fluid within the first intermetatarsal space. The degree of fluid is asymmetric and out of proportion to the degree of fluid typically expected in this region. Findings are compatible with intermetatarsal bursitis.

Fig. 31
Effusions

Sagittal T2 fat saturated images of the ankle demonstrate a subtalar effusion in this patient with a history of gout. While an effusion is a non specific finding it is often seen as an early manifestation of gout.

Fig. 32

Synovitis

Synovitis, while most commonly seen in the foot in patients with gout, can also manifest in other locations, including the wrist. Axial and coronal T2 fat saturated images of the wrist demonstrate thickening of the synovium surrounding the carpal bones consistent with synovitis.

Fig. 25
Fig. 24

T1 fat saturated post contrast images of the foot demonstrate synovial thickening and enhancement surrounding the first and second metatarsals, indicating synovitis.

Fig. 23

T1 fat saturated post contrast coronal and sagittal sequences demonstrate characteristic synovial enhancement and thickening consistent with synovitis.
**Synovitis**

T2 weighted fat saturated coronal and axial images demonstrate synovial thickening surrounding the first metatarsal head consistent with synovitis.

Fig. 22

**Erosions**

While the first metatarsal is the most commonly involved site for erosions in the foot, other metatarsals may be involved, as in this case. T1 axial, T1 axial fat saturated and T2 coronal fat saturated images demonstrate extensive erosions at the second metatarsal head.

Fig. 21
Fig. 20

T1 coronal sequence demonstrates multiple erosions of the tarsal bones and metatarsals in this patient with gout.

Fig. 19

The most common manifestation of gout is a soft tissue tophus adjacent to the head of the first metatarsal with associated erosions. Note the first metatarsal head erosions on T1 and T2 fat saturated imaging and adjacent enhancement of the tophus on T1 fat saturated post contrast imaging.
Tophi and erosions often times go hand in hand in patients with gout. This case demonstrates multiple erosions at the first metatarsal on T1 weighted sequences. Note the characteristic overhanging edges. T1 fat saturated post contrast sequence demonstrates an associated enhancing tophus.

Fig. 18

T1 sagittal sequence of the ankle demonstrate a characteristic erosion of the cuboid bone.

Fig. 17
Fig. 33

Sagittal and coronal T2 fat saturated images of the foot demonstrate an effusion at the first metatarsophalangeal joint in this patient with a history of gout.
Conclusion

- Common manifestations of gout on MRI include:
  - Erosions
  - Various types of tophi including calcified or soft tissue predominant tophi and intra-articular, extra-articular or intraosseous predominant locations
  - Synovitis
  - Tenosynovitis
  - Bursitis
  - Effusions

- While the 1st metatarsophalangeal joint is the most commonly involved site for gout, many other joints may manifest gout related abnormalities on MRI including the ankle, knee, and elbow

- Differential diagnostic considerations include (among many other entities) rheumatoid arthritis, pseudogout, psoriatic arthritis and septic arthritis

- MRI can be helpful in helping differentiate these entities from gout

References


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