

IMAGING IN LOWER EXTREMITY TRAUMA

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Plain radiographs with complimentary CT are the cornerstone in evaluating lower extremity trauma. Ultrasound will reveal muscle and tendinous injuries, but the method is largely operator-dependent. MRI, on the other hand, is the most versatile imaging method to evaluate bone and soft tissue injuries. In this presentation, I outline the use of MRI in the setting of lower extremity trauma, including selected trauma related to pelvic structures. The topics in this talk include most common fractures, easily missed fractures around the knee, occult fractures, to assess the extent of intra-articular fracture with associated soft tissue and ligamentous injuries. Moreover, the each imaging technique is briefly discussed with the emphasis of CT and MRI.

RADIOGRAPHY

Standard AP and lateral views are usually diagnostically adequate for assessment of joint and lower extremity bone trauma. In more complex anatomic joint structures, such as wrist, elbow, shoulder, ankle, and foot, however, superimposing bones make image interpretation challenging and less easy. Therefore additional views are needed. In general, diagnosis of fractures can be performed quickly using radiographs and it provides relevant information as to whether adjacent joints are involved and how the fracture fragments are positioned. In multitrauma patients and in severe comminuted joint fractures the quality of the radiographs may suffer from inappropriate positioning of the joint due to pain and from soft-tissue swelling of the acutely injured joint. Thus, additional imaging with other modalities is essential.

CT

MDCT allows for simultaneous acquisition of multiple sections within a single tube rotation and all scanners offer subsecond rotation speed, thus increasing performance substantially. The increased performance of MDCT can be invested in faster and longer scans, or thinner scans. Faster scanning reduces movement artifacts and longer scans can be taken in a single breath-hold, especially benefiting emergency trauma patients. Thinner sections make it possible to acquire a near isotropic dataset with high spatial resolution and reduced partial volume effects that allow volumetric imaging and reconstruction of arbitrary MPRs. The position of the body part scanned is not crucial, due to use of these high-quality reformats. This feature is extremely useful in imaging of the joints. Image noise grows as section collimation is reduced, and to maintain a low level of noise either the radiation dose needs to be raised or thicker sections reconstructed. In clinical practice, thicker sections are reconstructed from raw data, either axially or in any desired plane using MPR functionality. MDCT with MPR is helpful in disclosing complex joint fracture patterns in extremities where they reveal occult fractures and also the exact number of fracture components and their degree of displacement. The value of MDCT in the imaging of complex acetabular and pelvic ring fractures has been well established.

Although DSA that has been the reference standard for the diagnosis of traumatic vascular injuries, it is giving way to faster, less invasive and less personnel intensive imaging techniques, such as MDCT angiography. In spite of this, DSA still has a role in stab injuries, especially when catheter-based endovascular techniques for vascular trauma management are considered.

MRI

High-field MR scanners (1.5T) with proper equipment that includes multi-channel coil design with parallel imaging offer excellent image quality in reasonable time. Open-configuration scanners offer better access to patients with multiple trauma. The lower field strength (0.2-0.5 T), however, has the disadvantage of lower spatial resolution and increased imaging time. 3T scanners, on the other hand, offer excellent spatial resolution, increased signal-to-noise ratio (SNR) and eventually shorter imaging time.

Imaging protocols are designed according to anatomic target. As a rule of thumb, I first image with a large field-of-view (FOV), and then focus on the specific target. It is worthwhile to follow the scanning "on-line", as you may be able to tailor your protocol according to findings. Also, by doing this, you are able to give at least a provisional diagnosis to the clinician, who, based on my personal experience, will inquire after the diagnosis on an average of two minutes after the last scan.

Spin echo or fast-spin echo –based sequences are the workhorse of MSK trauma imaging. They offer good SNR and spatial resolution with relatively reasonable imaging time. Also, manipulating excitatory pulse characteristics, echo and repetition time these sequences provide a good soft-tissue contrast. Gradient echo –sequences (GE) are less commonly used, but due to their inherent physical properties this sequence may be used to reveal foreign bodies causing local field inhomogeneities. These areas are seen as signal void, so well seen using GE-sequences, that the phenomenon has been coined as "blooming effect". GE sequences do, however, offer thin slice thickness that may be useful in assessing avulsion fractures and intra-articular fragments and when visualization of small anatomic details are required. Assessing bone marrow pathology, the GE-sequence is notoriously inferior to spin-echo based sequences.

Since trauma is associated with haemorrhage and oedema to soft tissues, I usually start imaging using a fluid sensitive sequence STIR or T2-weighted with fat saturation using relatively large field of view. Usually the former offers more homogeneous suppression of fatty structures, and is less sensitive to field inhomogeneities caused by orthopaedic hardware. The disadvantage is poor SNR. Spectral fat-saturation, on the other hand, has better SNR, but is more sensitive to field inhomogeneities. This may be a problem when, for example, the imaging target is far from magnetic field isocenter, or the patient has orthopaedic hardware.

T1-weighted images reveal pathologic bone marrow, such as fracture-related oedema, and is very useful in evaluating muscles. Cortical structures are evaluated best with this sequence. Whereas fluid-sensitive sequences show fracture associated oedema, fracture line may actually be seen as a signal hypointensity in T1-weighted images. Sometimes the fracture line is less conspicuous. Then administration of i.v. contrast may be helpful. The T1 relaxation of the oedema surrounding fracture is shortened, making it brighter leaving the fracture-line black. This method is sometimes useful in evaluating stress fracture of the femoral neck, where the prompt diagnosis is of utmost importance. Also, i.v. contrast may be administered to assess the vascularity of non-unions.

T2-w sequences (without fat-suppression) delineate tendons and muscles well.. Although fat and fluid are bright on FSE (turbo spin-echo), muscle details are usually well seen. Proton-density images, with or without fat-suppression are useful in evaluating the menisci

The use of MR in orthopaedic trauma has mainly been limited by cost and availability. Also, the relatively long scanning time has been a limiting factor. In spite of these restrictions, MRI yields important information no other imaging modality can offer in patients who have sustained a musculoskeletal trauma.

COMMON FRACTURES IN PELVIS AND LOWER EXTREMITY

PELVIC RING WITHOUT DISRUPTION

- ✓ Avulsion fx's
- ✓ Isolated pelvic bone: iliac wing, lower sacrum, coccyx

PELVIC RING WITH DISRUPTION

- ✓ Lateral compression
- ✓ Anteroposterior compression
- ✓ Vertical shear
- ✓ Combined

SACRUM: ZONE I, II AND III

ACETABULUM

- ✓ 5 common fractures (90% of all acetabular fx's)
 - § both column
 - § T-shaped
 - § transverse + posterior wall
 - § transverse
 - § posterior wall

HIP AND PROXIMAL FEMUR

- ✓ Posterior and anterior dislocations
- ✓ Femoral head
- ✓ Femoral neck: subcapital and transcervical
- ✓ Trochanteric
- ✓ Intertrochanteric
- ✓ Subtrochanteric

PATELLA

- ✓ Transverse

- ✓ Vertical
- ✓ Stellate
- ✓ Lateral dislocation

KNEE

- ✓ Posterior and anterior dislocation
- ✓ Tibial plateau: I-VI
- ✓ Avulsions
 - § ACL
 - § PCL
 - § Segond

ANKLE

- ✓ A,B,C-type
- ✓ Maisonneuve
- ✓ Pilon
- ✓ Tillaux
- ✓ triplane fracture

HINDFOOT

- ✓ Subtalar dislocation
- ✓ Talus: head, neck, body, posterior and lateral process
- ✓ Calcaneus: w/wo subtalar joint involvement

MIDFOOT

- ✓ Navicular
- ✓ Cuboid
- ✓ Lisfranc injuries: homolateral, divergent

BASE OF V-MT

- ✓ Jones
- ✓ Avulsion fx

SELECTED INJURIES IN MRI

<p>HIP</p> <ul style="list-style-type: none"> ✓ occult fractures ✓ cartilaginous injuries and labral tears ✓ AVN ✓ stress fractures ✓ hamstring avulsions ✓ injuries to quadriceps origo 	<p>THIGH</p> <ul style="list-style-type: none"> ✓ stress fractures ✓ compartment syndromes 	<p>KNEE</p> <ul style="list-style-type: none"> ✓ tibial condylar fractures with associated soft tissue injuries. ✓ knee dislocations with arterial and nerve injuries ✓ growth plate injuries
<p>LEG</p> <ul style="list-style-type: none"> ✓ Compartment syndromes 	<p>ANKLE</p> <ul style="list-style-type: none"> ✓ periarticular soft-tissue ligamentous disruptions ✓ occult fractures ✓ osteochondral lesions 	<p>FOOT</p> <ul style="list-style-type: none"> ✓ Lisfranc fracture-dislocation ✓ stress fractures ✓ plantar fascia

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