Musculoskeletal imaging in sports medicine is a rapidly developing field, being driven by both continuously advancing technology and improved understanding of the disabilities that may result from sporting injuries, many of which can be minimised or avoided by early diagnosis and appropriate treatment.

Paradoxically, as imaging tests become ever more sophisticated and sensitive, the importance of clinical judgement in determining both when to order tests and the relevance of abnormal findings increases. This is because real but incidental anatomical derangements, such as normal developmental variants, and asymptomatic degenerative changes which become more prevalent with age and high-level sporting activity, are frequently detected. Studies have shown that subclinical pathological change is present in a large proportion of asymptomatic or minimally symptomatic athletes. It has long been recognised that even gross pathological derangements, such as osteoarthritic joints, intervertebral disc protrusions and rotator cuff tears, can sometimes be completely asymptomatic. Thus, physicians must always remember to “treat the patient, not the scan”.

Indications for imaging

The common-sense rule of only ordering a test if the result is likely to influence management applies. In sports medicine, a specific anatomical diagnosis is not always required and does not necessarily constitute best practice. For example, mild-to-moderate back pain in young adults without neurological signs may be appropriately managed with physiotherapy alone, irrespective of the actual anatomical diagnosis. A recent interesting study has found that in back pain, early use of computed tomography (CT) or magnetic resonance imaging (MRI) leads to slightly better patient outcomes without changing management. Despite this, the study concluded that whether such imaging was cost effective remained unresolved.

In general, the indications for imaging are as follows:

- When the clinical diagnosis is uncertain and management may be affected by one or more of the particular possibilities being considered.
- When clinical “red flags” are present and sinister or systemic abnormality must be excluded;
- When the clinical diagnosis is obvious, but the extent of injury or presence of complications is unclear and either of these considerations may affect management;
- When treatment has failed and the reasons for this are unclear (was the original diagnosis correct?),
- When objective evidence is required to document the existence, progression or resolution of disease (eg, medicolegal situations);
- When preoperative localisation or planning information is needed.

Imaging techniques

The selection of the best test or tests will vary, depending on (i) the provision of clinical diagnosis, (ii) the local availability of appropriate radiological equipment and expertise, (iii) patient considerations such as cost, convenience, and compliance, (iv) safety considerations such as patient age, radiation dose and contrast sensitivity, and (v) other costs such as that to the tax payer or insurance company. Radiation safety is an important consideration, as adverse effects are known to occur. In particular, multislice CT, which can readily generate large exposures, should be used judiciously. The United States Food and Drug Administration estimates that an effective dose of 10 mSv may carry a one in 2000 lifetime risk of inducing fatal cancer. A short list of relative radiation doses is given in Box 1. The actual dose delivered in any given CT examination can vary greatly, depending on the type of scanner and scan technique used. It has been estimated that over one million CT scans are performed each year in Australia, and that the collective radiation dose arising from these studies could be inducing as many as 280 fatal cancers per year. Thus, in

IMAGING SHOULD BE CONSIDERED ONLY AFTER A PROVISIONAL CLINICAL DIAGNOSIS IS REACHED, AND ONLY IF IT WILL INFLUENCE MANAGEMENT

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MJA PRACTICE ESSENTIALS — SPORTS MEDICINE

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Imaging should be considered only after a provisional clinical diagnosis is reached, and only if it will influence management

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• Imaging should only be undertaken if it is likely to influence patient management.
• The dose of ionising radiation to the patient should be considered.
• Requesting the appropriate imaging method requires an understanding of the pathological process.
• Plain x-ray should still generally be the first imaging technique; exceptions include some forms of superficial tendinopathy, in which ultrasound may be more appropriate, and situations where radiation exposure is contraindicated, such as in a pregnant patient.
• The cost of the examination to the patient and the community should also be considered (eg, ultrasound v magnetic resonance imaging).

When clinical “red flags” are present and sinister or systemic abnormality must be excluded;
sports medicine, where disease is not life-threatening, the question of whether CT scans or isotope bone scans are essential to management is important. For younger patients in particular, safer tests such as ultrasound or MRI should be used wherever they will provide equivalent diagnostic efficacy.

It is always important to provide a request form which offers a guiding differential diagnosis or asks specific questions that the radiologist must attempt to answer. This not only allows appropriate optimisation of imaging protocol, but also increases the likelihood of disease detection (because subtle or equivocal findings are easily overlooked if the clinical notes provided do not adequately direct the radiologist’s search pattern and analysis). It is worth asking your local radiologist for advice if uncertain about such issues of cost, access, accuracy, safety or the significance of the report findings.

Plain x-ray
This provides a comprehensive anatomical overview at low cost and relatively low radiation dose, and should generally be the first imaging test.17 Combined with the clinical assessment, plain films alone will often allow a reasonable provisional diagnosis and management plan to be formulated without the need for more sophisticated tests. Even when the clinical features suggest that an injury involves soft tissue structures alone, plain films may be required to detect important features that other tests may miss (eg, soft-tissue calcifications, foreign bodies, bone spurs, accessory centres of ossification, periosteal reactions, joint malalignments, old injuries and other predisposing conditions, clinically unsuspected fractures). X-rays that show no abnormalities are not a waste of time, as they help to exclude or reduce the likelihood of many conditions. Failure to obtain plain films can lead to significant errors in the interpretation of more sophisticated tests, such as MRI, bone scans or ultrasound.

Isotope bone scans
Isotope bone scans provide a “functional” image of current skeletal osteoblastic activity which is sensitive but non-specific. They are often used in sports medicine to confirm and localise a bone or joint abnormality before targeted characterisation by another form of imaging, but may also be used to diagnose a few specific conditions such as osteomyelitis, metastatic bone disease, and lytic or blastic bone lesions.

<table>
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<th>Case study 1 — knee pain</th>
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A 50-year-old, mainly sedentary, male ex-footballer with gradual onset knee pain. There are no mechanical symptoms such as locking. He has well-localised tenderness on the medial joint line and a mild effusion. He gets medial knee pain on squatting but can move his knee from full extension to full flexion without any catching (equivocal or negative McMurray’s test).

**Differential diagnosis:** Medial compartment osteoarthritis and/or degenerative posterior horn tear of the medial meniscus.

**Imaging options:** A plain x-ray series (with weightbearing views) is essential to determine the presence and degree of any degenerative change in the medial joint compartment, which dramatically affects management. At his age, severe degenerative changes may indicate definitive surgery, such as total or unicompartmental knee replacement. If the x-ray shows no degenerative changes, the likelihood of a clinically-relevant medial meniscal tear is significantly increased, as is the likelihood of knee arthroscopy giving an excellent result. It is in this scenario (clinical picture compatible with meniscal tear, but diagnosis uncertain) that an additional test such as magnetic resonance imaging (MRI) becomes valuable,18 as a confirmed diagnosis would alter the management (see Figure).

If the x-ray shows moderate degeneration of the medial compartment, but not to the degree of needing major surgery (yet), then the recommended management of this patient is generally to persist with conservative treatment (glucosamine, moderate activity, hyaluronic acid injections). In this situation, surgical management is unlikely to be indicated as there is no mechanical restriction of movement,19 which means an MRI is probably an over-investigation.

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conditions including long bone stress fracture, osteonecrosis, osteitis pubis, and reflex sympathetic dystrophy. The clinical context will heavily influence the interpretation of isotope scans, as a number of pathological processes (including degeneration, trauma, infection, tumour, and osteonecrosis) can produce the same appearance. As abnormalities appear on bone scans for many months after clinical resolution, this form of imaging should not be used for monitoring healing of a lesion.

Computed tomography
CT is the ideal imaging modality whenever the cortical and trabecular architecture of bone or the bony anatomy of complex joints must be further assessed. CT is better than MRI at showing fracture lines, small calcifications, loose bodies, subtle bone erosions, and bone mineral loss or destruction. CT has a role in assessing non-weightbearing joint alignment (eg, patellofemoral tracking disorders, sternoclavicular joint dislocation, or femoral anteversion). CT can be used to assist with guided injections into deep structures that are beyond the resolution of ultrasound (eg, sacroiliac joint, facet joint). CT can also be used to give the surgeon a better preoperative 3D understanding of complex bony derangements or prosthesis complications. While detection of focal lumbar disc protrusions by CT is equivalent to MRI, MRI should be used in most circumstances as it does not expose patients to radiation.

Magnetic resonance imaging
MRI provides a comprehensive, panoramic, and multi-planar image of both superficial and deep soft-tissue structures. Although MRI resolves bone mineral poorly, it is the ideal modality whenever a detailed characterisation of bone marrow disorder is sought. This gives MRI a special place in evaluating osteochondral injury, osteonecrosis, bone bruising, bone stress, transient osteoporosis of the hip, and tumours. MRI has equivalent sensitivity to isotope bone scanning for the detection of bone stress, but provides considerably more anatomical information without exposing patients to ionising radiation. MRI also provides excellent delineation of both deep and superficial soft tissues in a more panoramic and less operator-dependent format than ultrasound, and is the best non-invasive imaging test for injuries of articular cartilage and fibrocartilage (eg, meniscal tears). Some types of ligament, muscle and tendon injury are also best seen with MRI, especially when these involve deep or inconveniently positioned structures that do not afford ready ultrasound access. In recent years, MRI has been shown to be very useful in helping to provide a prognosis for muscle strain injuries in professional athletes (Box 2), although the cost makes it inappropriate as a routine test in amateurs (on the basis that management would not be changed). MRI may be contraindicated or complicated by factors such as cardiac pace-
markers, cerebral aneurysm clips, claustrophobia, inability to remain still, prostheses and other surgical hardware.

Under the current Australian health system, cost and access are also significant issues because Medicare rebates do not apply to MRI scans ordered by primary care providers (including sports physicians, even if they are consulted on a referral basis). For both CT and MRI examinations of joints where intra-articular abnormality is suspected (particularly for the hip and shoulder), joint surface resolution may be improved by the use of an intra-articular contrast material. The benefits of this must be weighed against the added patient discomfort and risks, such as allergic reaction, chemical synovitis or, rarely, septic arthritis.

Ultrasound

Ultrasound is a safe and powerful, but highly operator-dependent, method of imaging superficial soft tissues, especially tendons (e.g., rupture, adhesions, tendinitis) and associated structures such as bursae. Ultrasound is particularly useful for detecting radiolucent foreign bodies, ganglion cysts and other fluid collections, and small soft tissue masses. It is a targeted and interactive test in which the examiner is in the room with the patient, actively interrogating the site of symptoms and correlating clinical features such as localised tenderness directly with the imaging appearances. Ultrasound is cheaper, faster and better tolerated than MRI. It is often the best method of assessing soft tissue pathodynamics such as abnormal tendon glide, soft tissue impingement and hernial protrusion. Doppler techniques give ultrasound a role in some vascular conditions (e.g., arterial aneurysm, deep vein thrombosis). It also allows the accurate guidance of percutaneous therapeutic procedures such as injections.

Conclusions

New and impressive medical imaging techniques emerging over the last two decades have greatly expanded our ability to non-
Evidence-based recommendations

- Abnormal findings on scans do not necessarily indicate clinical relevance (Evidence level I [E1]; based on National Health and Medical Research Council levels of evidence)8. Many studies of asymptomatic patients have revealed a high incidence of radiological “abnormality”.2-7 While such lesions sometimes increase the risk of clinical syndromes developing, they should serve as a warning against injudicious ordering of imaging tests.
- Moderately severe chronic back pain without neurological symptoms and signs is generally treated in the same fashion whether or not three-dimensional imaging techniques are used (E1).8,9,20 However, a recent randomised controlled trial suggested that despite similar treatment, early imaging slightly, but significantly, improves outcome (E2).9
- Magnetic resonance imaging (MRI) of the knee is useful when the clinical diagnosis is equivocal,8 but not necessarily when the clinical diagnosis is clear.19 Studies comparing the accuracy of physical examination with that of MRI in diagnosing intra-articular knee disorders have generally found 70%-80% accuracy with both methods (E2).25
- Imaging techniques that involve ionising radiation (x-ray, CT scan, bone scan) may have the potential to be carcinogenic (E4).7,8

Invasively interrogate complex anatomical structures in fine detail, and to diagnose a variety of conditions in sports medicine. Nevertheless, the complicated array of available imaging technology now makes the choice of exactly which test to order, and when, challenging. In many situations, there are simply no authoritative guidelines available, and the choice of test may also be influenced by individual patient or local community circumstances.

It must never be forgotten that imaging does not replace or reduce the need for a thorough clinical evaluation. Such evaluation, coupled with knowledge of the relevant anatomy and an understanding of likely pathological conditions, remains the cornerstone of accurate diagnosis. Only when a provisional clinical diagnosis has been reached can a rational decision be made about the need for additional diagnostic tests and the significance of any subsequent results.

Competing interests

None identified.

References


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