Diagnostic Imaging Practice Guidelines for Musculoskeletal Complaints in Adults—An Evidence-Based Approach

Part 1: Lower Extremity Disorders

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Abstract

Purpose: The aim of this study was to develop evidence-based diagnostic imaging practice guidelines to assist chiropractors and other primary care providers in decision making for the appropriate use of diagnostic imaging of lower extremity disorders.

Methods: A comprehensive search of the English and French language literature was conducted using a combination of subject headings and keywords. The quality of the citations was assessed using the Quality of Diagnostic Accuracy Studies (QUADAS), the Appraisal of Guidelines Research and Evaluation (AGREE), and the Stroke Prevention and Educational Awareness Diffusion (SPREAD) evaluation tools. The Referral Guidelines for Imaging (Radiation Protection 118) coordinated by the European Commission served as the initial template. The first draft was sent for external review. A Delphi panel composed of international experts on the topic of musculoskeletal disorders in chiropractic radiology, clinical sciences, and research were invited to review and propose recommendations on the indications for diagnostic imaging. The guidelines were pilot tested and peer reviewed by field chiropractors, and by chiropractic and medical specialists. Recommendations were graded according to the strength of the evidence.

Results: Recommendations for diagnostic imaging guidelines of adult lower extremity disorders are provided, supported by more than 174 primary and secondary citations. Except for trauma, the overall quality of available literature is low. On average, 57 Delphi panelists completed 1 of 2 rounds, reaching more than 83% agreement on all 56 recommendations. Peer review by specialists reflected high levels of agreement, perceived ease of use of guidelines, and implementation feasibility.

Conclusions: The guidelines are intended to be used in conjunction with sound clinical judgment and experience and should be updated regularly. Dissemination and implementation strategies are discussed. Future research is needed to validate their content. (J Manipulative Physiol Ther 2007;30:684-717)

Key Indexing Terms: *Practice Guideline; Guideline; Diagnostic Imaging; Radiology, Diagnostic X-ray; Radiography; Adult; Musculoskeletal System; Pain; Lower Extremity; Hip; Knee; Ankle; Foot; Trauma*

Reporting of Topics Included in the Development of the Diagnostic Imaging Practice Guidelines[1]

An initial literature review considered 10 clinical questions pertaining to imaging of musculoskeletal conditions to evaluate the pertinence of developing diagnostic imaging guidelines. This initial review led to a research project divided into 9 phases: (1) literature search, (2) independent literature assessment, (3) guideline development specific recommendations, (4) first external review, (5) consensus panel (modified Delphi), (6) public Web site, (7) second external review, (8) final draft and grading of the recommendations, and (9) dissemination and implementation. Details of this study are published elsewhere.[2]

Focus

These diagnostic imaging guidelines concern adult musculoskeletal disorders of the lower extremities where conventional radiography and specialized imaging studies are deemed useful for diagnostic purposes.

Objectives

These proposed guidelines are intended to reduce unnecessary radiation exposure and the use of specialized imaging studies, increase examination precision, and decrease health care costs—all without compromising quality of care. The

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reasons for developing these guidelines include assisting current and future health care providers to make appropriate use of imaging studies, providing indications for the need of imaging studies according to current literature and expert consensus, and assisting in optimizing the use of limited available resources.

Target Users/Setting

Intended users of the guidelines are chiropractors and other primary health care providers prescribing diagnostic imaging studies. The setting in which these guidelines may be used include private clinics, outpatient clinics, and hospital emergency departments.

Target Population

The patient population eligible for guideline recommendations are adult patients presenting with musculoskeletal disorders of the lower extremities. Children and pregnant patients are excluded from these guideline recommendations.

Developers

The proposed guidelines are developed from the results of 9 distinct phases overseen by a research team composed of the 3 investigators with postgraduate education from 3 independent teaching institutions. The guidelines were further developed and peer reviewed by more than 60 chiropractic clinicians, academics, researchers, and a group of physicians.

Evidence Collection

Electronic searches in English and French language literature occurred, and cross-references were repeated on 3 different occasions between 2003 and 2006.

Methods for Synthesizing Evidence

1. Literature search and Independent literature assessment of spinal disorders: Quality of Diagnostic Accuracy Studies (QUADAS),[3] Appraisal of Guidelines Research and Evaluation (AGREE),[4] and Stroke Prevention and Educational Awareness Diffusion (SPREAD).[5]
2. Initial draft. Template based on European Commission classification (2001).[6]
3. Expert consensus. A 2-round modified Delphi process was used to generate consensus among an international panel of more than 60 experts in musculoskeletal disorders.

Recommendation Grading Criteria

The evaluation tool used was designed by the Scottish Intercollegiate Guidelines Network (SIGN) and adapted by the Stroke Prevention and Educational Awareness Diffusion (SPREAD group).[5,7]

Patient Preferences: Condition-Specific Imaging Guidelines

Integral to evidence-based health care, decisions regarding the use of imaging studies should be based on the best available evidence, and the experience and judgment of the clinician, while considering patient preference. A public member reviewed all documents and provided comments and suggestions.

Stakeholders and Editorial Independence

Pre-release Review. Before the release of the guidelines, the reliability of proposed recommendations was tested on specialists both in chiropractic and in medicine as well as on field chiropractors.

Potential Conflict of Interest. The research team involved in the development of these guidelines declares no existing or potential conflict of interest. No investigators have received, nor will receive, any personal financial benefits or derive any salary from this project.

Funding Sources/Sponsors.

1. Canadian Memorial Chiropractic College Post Graduate Education and Research (2005)
2. National Institutes of Health student grant (2006)
3. Canadian Chiropractic Protective Association (2006)

Updating/Revision

The literature review and the guidelines should be updated every 2 to 3 years.

Potential Benefits and Harm

These include selection of appropriate radiologic imaging procedures for evaluation of patients with musculoskeletal disorders of the lower extremities; and decreased unnecessary ionizing radiation exposure, decreased costs, and improved accessibility.

Dissemination/Implementation Considerations

Means of dissemination include publication; application to the National Guideline Clearinghouse; posting of the electronic document on various Web sites (malpractice insurance carriers, outpatient teaching clinics); educational intervention strategies (e-learning, community pilot studies); referral guidelines, reinforced by request checking and clinical management algorithms; promotion by national, provincial, and state organizations; and conferences.

Definitions, Patient Presentations, Recommendations, and Rationale

These topics are integral parts of each one of the three diagnostic imaging guidelines: lower extremity disorders, upper extremity disorders, and spine disorders. Results of the 9 phases of the research project are published elsewhere in this issue of the journal.[2]

Preliminary Considerations and Disclaimer

What is the Role of These Guidelines?

These evidence-based diagnostic imaging practice guidelines are intended to assist primary care providers and students in decision making regarding the appropriate use of diagnostic imaging for specific clinical presentations. The guidelines are intended to be used in conjunction with sound

clinical judgment and experience. For example, other special circumstances for radiographic imaging studies may include: patient unable to give a reliable history, crippling cancer phobia focused on back pain, need for immediate decision about career or athletic future or legal evaluation, history of significant radiographic abnormalities elsewhere reported to patient but no films or reliable report reasonably available, and history of finding from other study (eg, nuclear medicine or imaging of the pelvis) that requires radiograph for correlation.[8] Application of these guidelines should help avoid unnecessary radiographs, increase examination precision, and decrease health care costs without compromising the quality of care.

The descriptions of clinical presentations and proposed clinical diagnostic criteria, the recommendations for imaging studies, and the comments provided throughout this article are a synthesis of the vast body of literature consulted before and during the various phases of this research project. Where the literature was found to be of poor quality or absent, consensus based on expert opinion was used. Although the investigators and collaborators carefully searched for all relevant articles, it is probable that some have been missed. Furthermore, as many new important studies are published in the near future, these will be incorporated in subsequent revisions of the guidelines and recommendations may change accordingly.

What These Guidelines Do and What They Do Not Do

These guidelines are intended to address issues faced by first-contact professionals only. These guidelines do not address all possible conditions associated with musculoskeletal disorders, only those that account for most initial visits to a practitioner.

Like other diagnostic tests, imaging studies should only be considered if (*a*) they yield clinically important information beyond that obtained from the history and physical examination, (*b*) this information can potentially alter patient management, and (*c*) this altered management has a reasonable probability to improve patient outcomes.[9-11]

Investigators and collaborators in the development of these imaging guidelines believe that liability insurance companies, third-party payers, and courts of law should not rely solely on descriptions of patient presentations, proposed recommendations, and/or corresponding comments found throughout the documents because patient presentations are unique and the application of any guideline always requires clinical judgment and thus needs to be considered in the proper context. In addition, laws and regulations may vary between geographical regions and should be considered when applying the proposed indications for any imaging study.

What is Evidence-Based Health Care?

Evidence based is about tools, not about rules.[12] Evidence-based health care is an approach in which clinicians and health care professionals use the current best evidence in making decisions about the care of patients. It involves continuously and systematically searching, appraising, and incorporating contemporaneous research findings into clinical practice. The overall goal is improving patient care through life-long learning.[12,13]

Potential Disagreements

There are several reasons for disagreement within a guideline development group. These include differences in interpretation of the research literature, differences in personal experience, and different perceptions of the inherent risks and benefits of a procedure.[14] Divergent or competing guidelines on similar topics serve only to further confuse and frustrate practitioners.[15] In addition, the continued lack of unity among chiropractors hinders growth of the profession by limiting integration and cooperation within the greater health care system. Readers of any guidelines are advised to critically evaluate the methods used as well as the content of the recommendations before adopting them for use in practice.[16]

Standard Patient Management Activities

Standard patient management activities, including diagnostic assessment and follow-up, are integral components of every patient encounter.[17] Initial triage of patients with musculoskeletal disorders is a constant recommendation of various clinical guidelines.[18] Imaging studies are used most practically as confirmation studies once a working diagnosis is determined. The objective is to determine the presence of clinical indicators of serious pathologies (red flags) requiring diagnostic imaging, specialist referral, or urgent surgical intervention. When a practitioner recommends that a radiograph or other diagnostic imaging study be performed, and the patient refuses, the patient should be advised of the associated risks and implications and this should be recorded in the patient's records.

Duration of Disorders

In clinical practice, musculoskeletal disorders are generally divided into categories according to the duration of the patient complaint on initial presentation. These diagnostic imaging guidelines therefore consider the following categories of clinical presentations: acute extremity disorder (<4 weeks of duration), subacute extremity disorder (4-12 weeks of duration), and persistent/chronic extremity disorder (>12 weeks of duration).

Are there Potential Risks Associated with Conventional Radiographs?

Although somewhat controversial,[19-22] it is important to remember that health hazards of all forms of radiation are cumulative.[22-29] The Biological Effects of Ionizing Radiation (BEIR VII) 2005 report released by the National Academy of Sciences adds further support to the "linear-no-threshold" model of cancer risk from ionizing radiation exposure.[30] In summary, this report concludes that ionizing radiation is dangerous even at low doses and that there are no safe limits. Given the potential risks associated with conventional radiography, only appropriate clinical indications can justify its use.

Table 1. *Adult hip disorders*

Patient presentation	Recommendations	Comments
Adult patients with full or limited movement and nontraumatic hip pain of <4 wk of duration[40-42] **Symptoms are often transient.** History, type of pain, and site of pain are the most important features to direct the diagnostic strategy. Physical examination is primarily to discriminate between articular involvement and referred pain.[3] Each age and gender exhibit typical specific hip, pelvis, and proximal thigh problems and diseases.	**Radiographs not initially indicated** [C]	**Radiographs are typically not useful for referred pain:** Hip pain may originate from many other sources such as the lumbar spine, knee joint or intra-abdominal sites (urologic, gynecologic, gastrointestinal problems).[42,43] **Radiographs are typically not useful for:** trochanteric and iliopsoas bursitis, iliotibial band syndrome, meralgia paresthetica, labral tear, hip flexor, extensor or rotator muscle strain, and tendinitis.
General indications for radiographs include[43,44]: • Failed conservative treatment • Complex history • History of noninvestigated trauma • Significant unexplained hip pain with no previous films • Loss of mobility in undiagnosed condition • Acute or subacute onset of intermittent locking • Palpable enlarging mass Consult specific clinical diagnoses and related patient presentations for additional help in decision making. Presence of one red flag alone may not necessarily indicate the need for radiography	**If radiographs are indicated** [B] AP pelvis and AP frog leg views **Special investigations** [C]	**Critical exclusionary diagnoses include:** • Osteonecrosis[6] • Septic arthritis • Acute fractures and avulsion fractures • Malignant tumors • Also consider femoroacetabular impingement syndrome in patients aged 20–30 y (see congenital/developmental abnormalities)[45,46] • MRI is the procedure of choice to exclude osteonecrosis, marrow and joint disease including infection[43,47]
Specific clinical diagnoses		
1. Strain, tendinitis, or tendinosis Injury occurs at muscle or tendon attachment or open apophysis. Most likely occur in horse riders, skiers and skaters or from stepping in a hole.[48] History: • Often after eccentric ballistic muscle action (eg, basketball, football) Clinical features: • Pain aggravated by activity, resistance testing, and with length-tension evaluation (muscle stretch) • ''Snapping hip'' usually results from iliopsoas tendinitis (internal) or iliotibial band (external) involving both the bursa and tendon.[49] • Suspect adductor muscle strains with medial or anterior thigh pain aggravated by passive abduction or resisted adduction	**Radiographs indicated in suspected osseous avulsion fracture** [D] AP pelvis and AP frog leg views **Special investigations** [D]	Partial or complete avulsion (bone-tendon junction injury) may result from isolated trauma or repeated straining. Overall, avulsions are more frequent in the anterior pelvis.[50] Avulsion fracture of ischial tuberosity is a rare condition that generally occurs in young athletes.[51,52] Radiographs reveal displaced avulsion fragment, with bone erosion and proliferation.[53] Typical muscles and tendons involved: • Adductor longus • Rectus femoris • Hamstrings • Iliopsoas • MRI for soft tissue involvement (edema, hemorrhage, frank disruption) and bony abnormality[54–56] • US may demonstrate site and amount of tissue disruption.
2. Piriformis syndrome[57–61] Clinical features: • Dull posterior hip or buttock pain radiating down the leg • May mimic discogenic radicular pain and facet joint referred pain • Limping • Pain aggravated by active external rotation, passive internal rotation, or palpation of sciatic notch.	**Radiographs not initially indicated** [D] **Special investigations** [D]	• MRI if unresponsive to care to assess muscle asymmetry and sciatic nerve hyperintensity at the sciatic notch (specificity, 0.93; sensitivity, 0.64).[59] May exclude anatomical variations such as divisions of sciatic nerve splitting piriformis and predisposing nerve to compression. • MRI or US may reveal bursitis.

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Table I (*continued*)

Patient presentation	Recommendations	Comments
3. Nontraumatic trochanteric and iliopsoas bursitis	**Radiographs not initially indicated** [D]	
Clinical features: • Localized tenderness and pain • Moderate perceived weakness on resistive testing and length-tension evaluation (whereas true weakness may suggest abnormality such as avulsion of underlying muscle)[62]	**Special investigations** [D]	• MRI useful in chronic or recurrent bursitis and is most accurate for iliopsoas bursitis.[63] • US is a cost-effective, easy-to-perform, and fast alternative. However, it fails to demonstrate iliopsoas bursitis in about 40% of cases.[64]
4. Osteoporotic femoral neck fractures	**Radiographs indicated** [C]	**Urgent orthopedic referral necessary:**
Clinical features: • Patients typically >65 YOA • Often before or after a fall • Unable to walk • May exhibit shortening and external rotation of the affected limb and localized hip pain[65]	AP spot and AP pelvis view	Estimated elevated risk of osteoporotic hip fractures in females aged >50 y is 17.5% in Canada.[67] Hip fracture is the most costly result of osteoporosis as it always requires hospitalization, is fatal in 20% of cases, and permanently disables a further 50%. Only 30% recover fully; 1.7 million hip fractures occurred worldwide in 1990.[68]
Occasionally: • No history of trauma • Able to walk • Nonspecific leg discomfort • No obvious shortening or malrotation deformity[65,66]	**Special investigations** [D]	Counsel all women on the risk of osteoporosis and related fractures[69] and on rehabilitation[70] **Advanced imaging and specialist referral recommended** • If radiographs are negative but clinically suspected, consider MRI, CT, or NM. • Dual-energy x-ray absorptiometry recommended (see adult thoracic spine for details)
5. Septic arthritis of the hip[43]	**Radiographs indicated** [C]	**Emergency referral:**
Clinical features: • Significant pain on movement and weight bearing	AP spot and AP frog leg views	• Life-threatening disease in 2%–5% and high morbidity[42] • Laboratory tests are crucial.[43]
• Fever • Malaise	**Special investigations** [D]	• MRI is the imaging modality of choice for infection. • Joint aspiration or surgery[43,71] • NM very sensitive but not specific for suspected septic arthritis and osteomyelitis[41,43]
Consider obtaining radiographs in adult patients with chronic hip pain unresponsive to 4 wk of conservative care or if one of the following conditions is suspected[72–75]:	**Radiographs indicated** [D] AP spot and AP frog leg	**See specific clinical diagnoses below**
1. Congenital or developmental abnormalities 2. OA (limited ROM) 3. Inflammatory arthritis 4. Osteonecrosis	**Additional views:** AP pelvis in suspicion of congenital abnormality, osteonecrosis, inflammatory arthritis[76]	
5. Tumors 6. Stress fractures or undisplaced fractures.	**Special investigations** [D][72,74]	• Unenhanced MRI done 1st (highly sensitive) • MR arthrography • Anesthetic injection • Examination under local anesthesia • Diagnostic arthroscopy[77]
Specific clinical diagnoses		
1. Congenital/developmental abnormalities[45,46,78]	**Radiographs indicated** [D]	**Orthopedic referral recommended**
Plain film radiograph as primary investigation for chronic hip pain.	Standing AP pelvis and recumbent AP false profile view[46]	**(a) Acetabular dysplasia:** Radiographic findings:
(a) Acetabular dysplasia Exclude in athlete <30 YOA with chronic hip pain May be bilateral	**Additional views**[46]: Abduction view of the hip (to determine eligibility for joint preserving surgery)	• Abnormal CE angle • Increased acetabular slope • Nonspheroid or oval femoral head • >25% of femoral head outside acetabular cavity[64,79]

Table 1 (*continued*)

Patient presentation	Recommendations	Comments
(b) Labral tear and femoroacetabular impingement Clinical features: • "Knife sharp" groin pain • Painful giving way syndrome • Locking • Painful clunk or snapping hip • Painful apprehension tests (forced hyperextension-external rotation in slight abduction) • Painful impingement test (forced flexion adduction).	**Special investigations** [D]	**(b) Labral tear:** Radiographic findings: • Typically normal in labral tears • Unenhanced MRI for hip articular cartilage and labrum defects[80] • MRI arthrography has high accuracy (90%) and diagnostic arthroscopy with labral resection[79,81,82] **Labral tear MRI findings:** • Focal chondral defects • Synovitis • Unossified intra-articular bodies • Concomitant pathologic findings, such as intra-and extra-articular ganglia or edema of the subchondral bone, may lead to early OA. • (It is unclear if labral tear can lead to DJD)[83] • MR arthrography: provide for accurate diagnosis
2. Osteoarthritis (degenerative joint disease) Clinical features: • ≥40 YOA • Hip pain only with possible protective limp • Activity-induced symptoms that improve with rest • Stiffness: in the morning or with periods of inactivity • May be bilateral • Significant decrease in pain with weight loss and exercise in patient >60 YOA[84,85] **Test for ROM:** Restricted and painful internal rotation: 3 planes ROM limitations less sensitive but more specific.[86]	**Radiographs indicated** [B] AP spot and AP frog leg views	Patients >40 YOA with a new episode of hip pain present with evidence of DJD in 44% of cases[44] Independent predictive factors for progression of DJD of the hip: age, female sex, presence of hip pain, joint space width at baseline = .5 mm, and a Kellgren and Lawrence score of ≥2 at baseline (LOE III).[87] Monitoring: staging also useful for surgical consideration and rapid onset DJD.[53,88,89] Precise reproducible radiograph required.[90]
3. Inflammatory arthritis (seronegative and seropositive) Unrelenting morning stiffness >30 min, pain at rest, pain or stiffness better with light activity, polyarticular involvement, warmth, effusion, diffuse tenderness, decreased ROM; fever/chills or other systemic symptoms, responsive to NSAID/steroid, flexion and adduction contracture in long-standing arthritis RA diagnostic criteria (≥4 of 7 required)[91,92]: • Morning joint stiffness >1 h • Arthritis involving ≥3 joints for at least 6 wk • hand arthritis (wrist, MCP, PIP) • Symmetric arthritis • Rheumatoid nodules • Serum Rh factor • Radiographic changes Risk of osteonecrosis with high-dose corticosteroid therapy.	**Radiographs indicated** [D] AP spot and AP frog leg views AP pelvis may also be warranted as initial study to assess both hips **Special investigations**[75,78,80] [D] MRI highly sensitive and often more specific than US; detection of synovial pannus, erosions, cartilage loss, small subchondral cysts, and marrow edema distribution[93–95] US may show effusion and osseous erosions.[96]	**Rheumatology referral recommended if persistent inflammatory joint disease (>6–8 wk) even with analgesics and** NSAID.[91] Radiographic changes in suspected RA: symmetrical distribution; joint effusion, fusiform soft tissue swelling, diffuse joint space narrowing, regional osteoporosis, marginal/central erosions, subchondral bone cysts, and absence of osteophytes.[93] Laboratory tests necessary to exclude RA.[92] RA may involve all articular components (fibrous capsule, subchondral bone, cartilage) and extra-articular structures (bursae, tendon sheath).[93]
4. Osteonecrosis (avascular necrosis)[43,47,76,97] Clinical features: • Most common in those <50 YOA • M:F= 8:1; in younger patients, M:F= 4.2:1 • Progressive groin pain that may refer to the knee • Early stages: normal ROM	**Radiographs indicated** [B] AP spot and AP frog leg views Consider AP pelvis as initial examination as condition may be bilateral	**Orthopedic referral recommended** Abnormal radiographic appearance in established disease. Staging is important for osteonecrosis natural history and indication for treatment. Osteonecrosis results in 10% of total hip arthroplasties in United States.[42]

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Table 1 (*continued*)

Patient presentation	Recommendations	Comments
• Advanced stages: limitation of extension, internal rotation and abduction; limping and atrophy		
Risk factors: • Systemic corticosteroids • Alcohol abuse • Radiation therapy • Chemotherapy • Metabolic disease • Some autoimmune conditions • Coagulopathies • Deep sea diving/saturation diving • Pregnancy	**Special investigations** [B]	**Advanced imaging and specialist referral recommended** MRI useful when radiographs are normal, especially in high-risk patients. Also NM and CT (when MRI unavailable)[43,97]
5. Tumors and metastatic lesions[43,47,60,76] No specific clinical features; Spontaneous pathologic fracture often first sign of metastasis from breast, lung, or prostate cancer	**Radiographs indicated** [D] AP spot and AP frog leg views	**Orthopedic referral essential** Metastatic disease, multiple myeloma, or chondrosarcoma involving the pelvis or femur are not uncommon in older patients with hip pain.
	Special investigations [D]	**Advanced imaging recommended:** • NM, CT, MRI
6. Stress (fatigue or insufficiency) fractures[65,98] Exertional anterior hip pain, especially after an increase in training regimen; chronic repetitive overloads, typically in athletes or reduced mechanical bone properties (athletic amenorrhea, osteoporosis, corticosteroid use)[99]	**Radiographs indicated** [D] AP spot and AP frog leg views If radiograph is inconclusive, re-radiograph after 10–14 d of restricted use before proceeding to advanced imaging.	**Orthopedic referral recommended** **Advanced imaging recommended** • Bone scan, MRI, or CT in suspected occult, osteoporotic, or stress fractures[98]
	Special investigations [D]	
Patient presentation		
Adult patients with significant hip trauma Delay in recognition and reduction of acute dislocation, fracture, and fracture-dislocation of hip leads to preventable complications and morbidity (LOE III).[100,101]	**Radiographs indicated** [C] AP pelvis, AP centered of hip, right and left obliques of the pelvis, and true lateral views[102]	The degree and nature of the trauma and age of the patient may warrant only routine images. Advanced imaging and specialist referral recommended:
	Special investigations [C]	• MRI for patients with significant hip pain after injury, especially when unable to bear weight; also to exclude occult fracture and possible labral tear.[98]

NSAID, Nonsteroidal anti-inflammatory drug.

Table 2. *Adult knee disorders*

Patient presentation	Recommendations	Comments
Adult patients with nontraumatic knee pain of <4 wk of duration Symptoms frequently arise from soft tissues not seen on radiographs.[43,103] Physical examination should include lower back, pelvis, hip, foot, and ankle as pain may be referred.	**Radiographs not initially indicated** [C]	Consider possible fractures even with trivial trauma in older patients (see Ottawa Knee rules)

Table 2 (*continued*)

Patient presentation	Recommendations	Comments
General indications for knee radiographs include[43,44,104]: • History of noninvestigated trauma (with signs from the OKR—see below) • Complex history • Significant unexplained effusion with no radiographs • Loss of mobility in undiagnosed condition • Acute/subacute onset • Intermittent locking • Unrelieved by 4 wk of conservative care • Palpable enlarging mass • Painful prosthesis Presence of one red flag alone may not necessarily indicate the need for radiography. See Malanga et al[104] for additional reading on physical examination of the knee.	**When radiographs are indicated or unless otherwise specified** [C] • Standing AP views for joint space integrity • Consider recumbent AP views if osseous detail is important. • Lateral view • Tunnel (intercondylar) view **Special investigations** [C]	**Critical exclusionary diagnoses include:** • Occult fractures • Septic arthritis • Osteonecrosis • Infection • Tumors • US useful to visualize superficial soft tissue structures (tendons, collateral ligament bursae); US less reliable for internal structures[105,106] • May be able to differentiate between degenerative and inflammatory causes of painful knee[103] • MRI best for internal derangements and can often prevent unnecessary knee arthroscopy[43,107]
Specific clinical diagnoses **1. Osteoarthritis (OA)**[43,108–110] The clinical criteria for OA of the knee are: If at least 3 of the following are present, sensitivity for OA is 0.95 and specificity is 0.69. If 4 criteria are present, sensitivity is 0.84 but specificity is 0.89. History: • >50 YOA • Morning joint stiffness <30 min Physical examination: • Crepitation • Bony tenderness • Bony enlargement • No palpable warmth • Other characteristics include long-standing pain, no extra-articular symptoms; aggravated by weight bearing, climbing stairs, exercise; nonresponsive to NSAID or corticosteroid medication; relieved with rest; deformity or fixed contracture, joint effusion; insidious onset.	**Radiographs indicated if unrelieved by 4 wk of conservative care** [B] AP, lateral, and intercondylar views if radiographs are indicated Annual radiographic evaluation not indicated as changes are often subtle and of doubtful clinical importance.[111] **Additional views:** 45° (oblique) views if signs and symptoms do not correlate with standard views **Special investigations** [B]	The prevalence of OA as the cause of knee pain among adults is 34%. OA is generally a chronic condition. However, patients sometimes present with an acute exacerbation. Radiographic findings of OA changes are helpful when diagnosis is uncertain.[107,112] Radiologic changes not strongly related to severity of joint pain or disability;[113–116] trial of conservative treatment appropriate if no effusion or a small effusion is present • US or MRI indicated if significant effusion and/or loss of joint space[117]
2. Inflammatory arthritis[73,91,109] (seronegative and seropositive) Diagnosis of inflammatory arthritis of the knee is primarily based on history and physical examination: • Unrelenting morning stiffness >30 min • Pain at rest • Pain or stiffness better with light activity (during remission) • Polyarticular involvement, especially the hands • Palpable warmth • Joint effusion • Decreased ROM • Fever/chills or other systemic symptoms • Responsive to NSAID or corticosteroid medication • Flexion and adduction contracture in long-standing arthritis See also hip section for RA diagnostic criteria	**Radiographs indicated** [D] Consider bilateral AP standing views **Special investigations:** [C]	**Rheumatology referral recommended if persistent inflammatory joint disease (>6–8 wk) even with analgesics and NSAID**[91] Specialized care necessary if incapacitating instability, deformity, or pain See hip section for radiographic changes in RA[93] Laboratory tests necessary to exclude RA[92] • US and MRI may aid in staging and as indicator of disease progression.[43,75,118,119] • Knee aspiration if positive for effusion

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Table 2 (*continued*)

Patient presentation	Recommendations	Comments
3. Bursitis/tendinitis/strain/tendinosis Clinical features: • Related to or aggravated by activity • Relieved or diminished symptoms at rest • Point tenderness • Localized swelling (extra-articular)	**Radiographs not routinely indicated unless** [D] • Unrelieved by 4 wk of conservative care • Suspected avulsion fracture[120] • Underlying arthropathy **Special investigations** [D]	 • MRI[120–122] • US: puncture of a popliteal cyst and corticosteroid injection can be done under US guidance[123]
4. Anterior knee pain Clinical features: • Insidious onset • Aggravated with steps/incline/rising from chair • Stiffness with rest or gliding • Pseudolocking or giving way • Tender patellar facets • Positive apprehension tests • Crepitation • Abnormal Q angle Clinical tests for the diagnosis of chondromalacia patella have low sensitivity, specificity, predictive values, and accuracy compared with tests for arthroscopy.[124]	**Radiographs indicated if** [C] Unrelieved by 4 wk of conservative care Suspected fracture Underlying arthropathy **Additional views:** Tangential patellar views to evaluate for chondromalacia, patellar tilt, or subluxation Stress radiographs to evaluate for patellofemoral instability (stress view: valgus and internal rotation at 45° of knee flexion)[125] **Special investigations** [C]	 • High-field MRI for chondromalacia and synovial plicae[47,122,125–128] • Contrast CT arthrography if MRI unavailable
5. Internal joint derangement[43,110] Clinical features: History • Acute or subacute onset • Intermittent locking and/or giving way • Crepitation, snapping, and popping • Worse with activity • Improved with rest (the accuracy of the clinical history in patients with suspected torn ligament or meniscus is unknown) Physical examination: • Joint line tenderness • Swelling and joint effusion • Loss of ROM Individual physical tests for meniscal lesions have little diagnostic value (meta-analysis.)[129] However, the accuracy increased when orthopedic tests are used in combination for meniscal and ligamentous tear, suggesting physical examination is usually normal in patients without damage to these structures (see comments).[110]	**Radiographs indicated if unrelieved by 4 wk of conservative care** [B] Standard AP, lateral views if necessary after 4 wk **Additional views:** Tunnel, standing lateral, standing oblique **Special investigations** [C] If diagnosis not well established from history, examination and radiographs or in the absence of clinical improvement	**Orthopedic referral or co-management recommended** It is important to note that radiographs often fail to demonstrate the cause of pain. Possible injuries: • Intra-articular body • Meniscal tear • Ligamentous injury • Avulsion fracture • Osteochondritis dissecans • OA • MRI is gold standard for internal knee derangements such as meniscal and ligamentous injuries.[43,130,131] • Spiral CT arthrography if MRI unavailable.[103,132] **Physical examination**[104,110]: Meniscal tear: joint line tenderness has a sensitivity of 0.76 (CI, 0.65–0.87) but low specificity, whereas McMuray test has a low sensitivity but high specificity (0.97; CI, 0.87–0.99). The Ege's test (weight-bearing McMurray's test) may be superior (84%, 0.64, and 0.90 for accuracy, sensitivity, and specificity, respectively) Ligamentous tear: the best studied tests are the Lachman maneuver (sensitivity, 0.87 [CI, 0.76–0.98]); specificity, (0.93 [CI, 0.89–0.96]), the pivot test (lower sensitivity but higher specificity (0.97 [CI, 0.93–0.99]), and the Anterior Drawer Test (low sensitivity but specificity of 0.87 [CI, 0.83–0.97]). CI of 95%

Table 2 (*continued*)

Patient presentation	Recommendations	Comments
Adult with acute knee injury but negative findings for the OKR indicates that a fracture is very unlikely.[133–137] High sensitivity (>0.98) for fractures **OKR:** If the patient meets the following criteria after an acute knee injury, they do not require radiographs to look for a fracture: • Patient <55 YOA • Can walk 4 weight-bearing steps immediately after the injury and at presentation without a limp • No isolated tenderness of the head of fibula or patella • Able to flex knee >90° May have a history of torsional injury and/or mild clinical signs (no immediate swelling, heat, ecchymosis, abrasion, or laceration)	**Radiographs not routinely indicated** [B]	Patient should be advised to return for follow-up if their pain has not improved in 7 d.[6]
Adult with acute knee injury and positive findings for the OKR[133–140] Radiographs required only in the presence of postinjury knee pain *and* any one of the following findings: • ≥55 YOA • Isolated tenderness at the head of the fibula or patella • Inability to flex knee >90° • Inability to walk 4 weight-bearing steps both immediately and at presentation Radiographs should also be obtained in the presence of obvious deformity or mass. The following factors exclude patients from the OKR: • <18 YOA • Pregnancy • Isolated skin injury • Referred with outside films • 7 d since injury • Multiple injuries • Altered level of consciousness • Paraplegic	**Radiographs indicated in the presence of one or more of the OKR criteria** [A] AP supine and lateral views **Additional views:** Bilateral oblique, tunnel, and tangential views **Special investigations** [C]	If radiographs are negative, but clinical signs are persistent, repeat films should be obtained 7–10 d after onset. Callus or deformity may become visible in the first month. Knee fractures usually accompanied by ligamentous or meniscal damage[6] (see internal joint derangement) Possible osseous injuries: • Tibial plateau fracture • Anterior tibial spine fracture • Small intra-articular bone fragments • Segond fracture (underlying ACL tear) • Intra-articular fractures (lipohemarthrosis sign on horizontal beam radiograph) **Advanced imaging and orthopedic referral recommended:** • Valgus stress radiographs under general anesthesia[125] • MRI is the modality of choice for initial investigation of knee trauma. • CT, US, and angiogram may be needed for additional information[6,132–134]

CI, Confidence interval; *OKR*, Ottawa Knee Rules.

Table 3. *Adult ankle and foot disorders*

Patient presentation	Recommendations	Comments
Adult with acute ankle and foot injury but negative findings on the OAR[57,141–149] OAR: high-sensitivity (>0.89) for fractures. Consider radiographs only of patients excluded from the OAR: • Multiple injuries • Isolated skin injury • 10 d since injury • Obvious deformity of ankle or foot	**Radiographs not routinely indicated** [B]	Only rarely are radiographs of foot and ankle indicated together. Clinical abnormalities are usually confined to foot or ankle[6] Patient satisfaction does not appear to be related to the decision to order ankle radiographs.[150]

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Table 3 (*continued*)

Patient presentation	Recommendations	Comments
• Altered sensorium: cognitive or sensory impairment (neurologic deficit), head trauma, intoxicated Pregnancy also excluded from OAR[142]		
Adult with acute ankle and foot injury and positive findings on the OAR[43,141–150]	**Ankle radiographs indicated** [B] AP ankle, 20° medial oblique (mortise view) and lateral (include base of fifth metatarsal)	Whether radiographs are ordered or not, patient should be advised to return for follow-up radiographs if their pain or ability to bear weight has not improved in 7 days.[6]
(a) Ankle (positive OAR) Radiographs required only if there is pain in the malleolar zone *and* any of these findings: • Bone tenderness of distal fibula along posterior edge or tip of lateral malleolus (distal 6 cm) • Bone tenderness of distal tibia along posterior edge or tip of medial malleolus (distal 6 cm) • Inability to bear weight both immediately and in clinic Also consider taking ankle radiographs in: • Older patients with malleolar tenderness and pronounced soft tissue edema • Presence of positive OAR foot findings	**Additional views** [D] Stress radiographs after distal fibular fracture helpful preoperatively to determine deltoid ligament status in orthopedic setting[151–153]	
(b) Foot (positive OAR)[43,141–149] Radiograph required only if there is pain in the midfoot zone and any of these findings: • Bone tenderness of base of fifth metatarsal • Bone tenderness of navicular bone • Unable to bear weight both immediately and in clinic	**Foot radiographs indicated** [B] When feasible, weight-bearing foot AP, lateral, medial oblique views. Comparison views (of normal foot) may be helpful[154] **Additional view** Tangential view of calcaneus for heel trauma cases	Look for fracture-dislocation (Lisfranc) as it has been estimated that 20% of Lisfranc injuries are missed on initial radiography, in which case, sequelae can be severe.[155-157] (non-weight-bearing views can be normal) For possible stress fracture, see chronic foot pain-forefoot section (C3).
	Special investigations for ankle and foot [D]	**Advanced imaging and orthopedic referral recommended:** • MRI or CT appropriate in presence of significant pain and disability and negative radiographs[158] • Fluoroscopic stress examination under anesthesia to assess ankle instability • NM for persisting symptoms to exclude stress fracture
Adult with acute toe injury Consider obtaining foot radiographs in presence of significant metatarsal pain (see OAR-foot)	**Radiographs indicated** [GPP] AP, oblique, and lateral views limited to the toes	Radiography of the foot not required in the absence of metatarsal injury and normal physical exam
Adult with chronic ankle and tarsal pain[159] Radiographs routinely obtained as first option to exclude: • Arthritis • Infection • Fracture and stress fracture • Neoplasm	**Radiographs indicated** [D] AP ankle, lateral, medial oblique (mortise) views (Medial oblique view helps evaluate the talocalcaneal relationship and lateral malleolus)	When an osteochondral fragment can be seen on a radiograph, ligamentous injury is usually detectable clinically. If radiograph appears normal with clearly abnormal clinical examination: MRI and diagnostic anesthetic injection may be indicated depending on pain, severity, and disability.
Specific indications for radiographs include[159,160]: • Suspected osteochondral lesion/stress fracture • Suspected tendinopathy with possible inflammatory arthritis • Possible ankle instability; Single-leg jump test as clinical indicator of functional instability	**Additional view:** Stress radiographs may be considered, but little agreement exists as to which technique.[162–164] **Special investigations** [D]	MRI is the gold standard for musculoskeletal assessment if radiography is positive or if unrelieved by 4 wk of conservative care.[158]

Table 3 (*continued*)

Patient presentation	Recommendations	Comments
• Noninvestigated chronic ankle and tarsal pain • Multiple sites of degenerative joint disease as visualized on radiographs of other regions • Possible operative candidate For more information, see Grassi et al.[161]		• MRI needed to exclude posttraumatic osteochondritis dissecans in ankle pain persisting> 6–8 wk • Contrast-enhanced, fat-suppressed, 3D, fast-gradient (or equivalent) MRI may be useful in diagnosing synovitis and soft tissue impingement.
Specific clinical diagnoses **1. Impingement syndromes**[160,165] Easily forgettable minor injuries may cause impingement syndromes; often mistaken for arthritis Findings most strongly associated with abnormality at arthroscopy[166]: • Anterolateral tenderness • Swelling • Pain on single-leg squatting • Pain on ankle dorsiflexion and eversion	**Radiographs indicated** [D] AP ankle, lateral, and mortise views **Special investigations** [D] For all suspected impingement syndromes with positive radiographs or unrelieved by 4 wk of conservative care:	Radiographs may appear normal as soft tissue causes of impingement such as synovial hypertrophy are not visualized • Accuracy and role of CT, US, and MR arthrography not clearly established for ankle impingement syndromes[167] • Contrast-enhanced, fat-suppressed, 3D, fast-gradient MRI may be indicated depending on pain, severity, and disability (sensitivity, 0.92; specificity, 0.84; accuracy, 87%).[166]
(a) Anterolateral impingement Clinical features: • Mechanism: inversion injury • Pain and localized tenderness in region of anteroinferior tibiofibular and/or anterior talofibular ligament • Positive impingement sign (sensitivity, 0.95; specificity, 0.88)[168]	**Radiographs indicated** [D] AP, lateral, and mortise ankle views **Additional view:** **Special investigations** (see above):	Possible radiographic findings: • Small osteophyte on the anterior tibial margin • 50% have increased anterior translation of talar dome on stress radiographs. However, clinical significance of stress test remains unanswered.[162–164] Stress radiographs may be considered
(b) Anterior impingement • Clinical features: • Mechanism: supination or repeated dorsiflexion injury • Anterior pain • Painful and restricted dorsiflexion	**Radiographs indicated** [D] AP, lateral, and mortise ankle views **Special investigations** (see above):	Possible radiographic findings: • Osteophytes involving the distal tibia and the talar neck • Seen best on mortise views
(c) Anteromedial impingement Clinical features: • Mechanism: inversion injury or ankle/talar fracture • Anteromedial pain and tenderness • Swelling • Pain and restriction on dorsiflexion and supination	**Radiographs indicated** [D] AP, lateral, and mortise ankle views **Special investigations** (see above):	Possible radiographic findings: • Osteophytes involving the anteromedial talus
(d) Posterior impingement Clinical features: • Mechanism: impingement of os trigonum between talus and posterior tibia • Common in ballet dancers • Pain elicited with full weight-bearing in maximum plantar flexion, especially when os trigonum is present • Tenderness behind lateral malleolus • Pain with passive plantar flexion	**Radiographs indicated** [D] AP, lateral, and mortise ankle views **Special investigations** [D]	Possible radiographic findings: os trigonum • MRI for os trigonum syndrome[169]
2. Peroneal tendinosis Clinical features: • Lateral hindfoot pain • Cavovalgus foot deformity • Frequently affected in RA	**Radiographs not routinely indicated** [D] Unless unrelieved by 4 wk of conservative care or patient has a suspected inflammatory arthritis[170] **Special investigations** [D]	• MRI or US if there are signs of popping or clicking with foot eversion[170–174]
3. Lateral premalleolar bursitis Clinical features: • Adventitious bursa develops in people sitting with inverted and plantar flexed feet	**Radiographs not routinely indicated** [GPP] **Special investigations** [GPP]	• US if unrelieved by 4 wk of conservative care

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Table 3 (*continued*)

Patient presentation	Recommendations	Comments
4. Tarsal tunnel syndrome[58,175,176] Clinical features: • Tingling pain and burning over the sole of the foot after prolonged standing or walking • Worse at night in some • Positive Tinel sign • Positive nerve compression test • 2-Point discrimination • Hypoesthesia on sole of foot • Rare weakness of toe flexion	**Radiographs not routinely indicated** [D] **Special investigations**[175–179]: [D] • US or MRI for nerve and other soft tissue visualization • CT for bony abnormalities • Sensory conduction velocity and distal motor latency useful for diagnosis and treatment progression	MRI best for differential diagnosis of the following: • Interdigital neuroma • Plantar fascitis • Tibialis posterior tenosynovitis • Tarsal coalition Consider local injection therapy for persistent pain and disability in cases of failed conservative therapy.[180]
Adult with chronic foot pain[181,182] Differential diagnosis: • Common complications of diabetes mellitus ○ Neuroarthropathy ○ Foot infection • Arthritis ○ Most of the common forms of arthritis affect the feet and can cause foot pain • Vasculitis • Neurologic involvement ○ Polyneuropathies ○ Cervical myelopathies ○ Sciatica ○ Mononeuritis multiplex	**Radiographs indicated** [C] Non–weight-bearing AP, lateral, medial, and lateral oblique views **Additional views:** • Lateral views for toes • Axial and lateromedial tangential views for sesamoid bones **Special investigations** [D]	Medial oblique helps evaluate forefoot and lateral oblique the tarsal and Chopart joints. In suspected RA, foot radiographs may show erosions even when symptomatic hand(s) appear normal.[6] High prevalence of midfoot and forefoot involvement in RA (53%–92%). Hindfoot and ankle affected later.[183,184] Laboratory investigations (blood and synovial fluid) recommended: • NM, MRI, US, arthrography may be useful[181,182]
A. Hindfoot-heel pain[43,161,182,185] Differential diagnosis: • Plantar fasciitis (common) • Calcaneal stress fracture • Tarsal tunnel syndrome • Diabetes mellitus • Long-term hemodialysis • Achilles or plantar enthesopathy • Inflammatory arthritis ○ Consider reactive arthritis (Reiter syndrome) with bilateral heel pain in young patient (second decade) with heel pain and toe inflammation	**Radiographs indicated only in specific circumstances** [C] AP, lateral, and medial oblique views of the foot **Additional views:** Tangential view of the calcaneus and lateral calcaneus view **Special investigations**[43,103]: [D]	Radiographs used to exclude trauma of the calcaneus and tarsal coalition • MRI if unrelieved by 4 wk of conservative care or before orthopedic or pediatric referral • Achilles enthesopathy: power Doppler sonography may show neovascularization that may be the cause of pain
Specific clinical diagnoses		
A1. Plantar fasciitis and calcaneal enthesophyte (spur)[43,182] Clinical features: • PF is one of the most common soft tissue foot disorders • Hyperesthesia over the plantar fascia • Risk factors[186]: ○ Decreased ankle dorsiflexion (≤0°) ○ Being on feet most of working day ○ Obesity (body mass index >30 kg/m^2)	**Radiographs not routinely indicated except in young athlete** [B] AP, lateral, and oblique views **Special investigations** [D]	Plantar spurs are common incidental findings. The cause of the pain is seldom detected on radiograph. Most patients can be managed without imaging. Consider ankle dorsiflexion night splinting for treatment of recalcitrant PF[187,188] • US may be initial step for advanced imaging (readily available, highly sensitive, low-cost, and radiation-free).[189] • Doppler/power US improves US value[190] • US, MRI, and bone scan are more sensitive in demonstrating inflammatory changes and thickening of the plantar aponeurosis in PF.[43,191,192]

Table 3 (*continued*)

Patient presentation	Recommendations	Comments
A2. Sinus tarsi syndrome Clinical features: • Mechanism: inversion injury or inflammatory joint diseases • Lateral foot pain • Perceived foot instability • Tenderness of the sinus tarsi	**Radiographs not initially indicated [D]**	Radiographs generally not valuable in this assessment. Furthermore, radiography does not depict any signs of hindfoot instability unless stress views are performed.[194] Sinus tarsi syndrome may result in OA of subtalar joint.
No agreement on pathognomonic history, clinical tests, or imaging studies that could help in confirming the diagnosis or establishing the etiology; may be related to instability of the subtalar joint[193]	**Special investigations** [D]	• MRI if unrelieved by 4 wk of conservative care: may be helpful for detecting subtle unilateral deformities[195]
B. Midfoot pain (nontraumatic)[161] Midfoot pain usually self-limiting Differential diagnosis: • RA • Psoriatic arthritis • Reactive arthritis (Reiter disease) • Gout • Diabetic neuroarthropathy • Diabetic infection	**Radiographs indicated if unrelieved by 4 wk of conservative care or in suspected inflammatory arthritis** [D] AP, medial oblique, and lateral views of the foot **Additional views:** Weight-bearing ankle series may be useful **Special investigations** [GPP] If radiography is positive or if unrelieved by 4 wk of conservative care:	Midfoot erosive disease difficult to assess on radiographs • CT or MRI warranted in suspected or proven disease, but negative/equivocal radiographs. White blood cell tagged bone scan to differentiate between infection and diabetic neuroathropathy
Specific clinical diagnoses		
B1. Acquired flat foot with posterior tibial tendon dysfunction/rupture[196–199] Posterior tendon rupture results in: • Acquired flatfoot • Valgus hindfoot • Forefoot abduction Clinical features: • Medial ankle/foot pain initially • May lead to disabling weight bearing symptoms • Talonavicular subluxation • Difficulty or inability to perform single-limb heel rise • Weak resisted inversion of fully flexed foot	**Radiographs indicated if unrelieved by 4 wk of conservative care or in suspected inflammatory arthritis** [D] AP, medial oblique, and lateral foot radiographs **Additional views:** Weight-bearing ankle series may be useful **Special investigations** [D]	Other causes of flatfoot • Inflammatory arthritis • Tarsometatarsal OA • Tarsal coalition • Neuropathic arthropathy • Traumatic ligament disruption • Neuromuscular diseases • MRI better at differential diagnosis of medial ankle/foot pain. • US may be useful For review of MRI usefulness, see Yu and Tanner.[200]
B2. Navicular tuberosity pain and tenderness[182] Potential painful normal variants such as accessory navicular bone (4%–21% of the population) have been described. Painful fibro-osseous junction of the accessory bone	**Radiographs indicated if unrelieved by 4 wk of conservative care** [C] AP, medial oblique, and lateral foot views **Special investigations** [GPP]	 • MRI to differentiate accessory navicular from an avulsion fracture • NM may be useful to help identify or confirm site of pain.
B3. Complex regional pain syndrome Synonyms: • Reflex sympathetic dystrophy • Sudek's atrophy Clinical features: • Pain • Tenderness • Swelling • Diminished motor function	**Radiographs indicated** [D] AP, lateral, and medial oblique views of the foot **Special investigations** [D]	Diffuse osteopenia seen in 70% of cases. **Advanced imaging and orthopedic referral recommended:** • MRI is useful in detecting numerous soft tissue and earlier bone and joint processes that are not depicted or as well characterized with other imaging modalities.[200]

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Table 3 (*continued*)

Patient presentation	Recommendations	Comments
• Vasomotor and sudomotor instability Associated conditions: • Fractures or other trauma • CNS and spinal disorders • Peripheral nerve injury[148]		• 3-Phase NM scan recommended if radiograph is not diagnostic (sensitivity, 0.100; specificity, 0.80; positive predictive value, 54%; negative predictive value: 100%)
Specific clinical diagnoses		
C. Forefoot pain Common site of foot pain Etiologies not easily identifiable by physical examination[201] See recommendations for the following specific clinical diagnoses: C1. Metatarsal bursitis C2. Morton neuroma[182] C3. Stress fracture[4] C4. Osteonecrosis C5. Hallux rigidus and hallux valgus[4] C6. Sesamoiditis	**Radiographs not routinely indicated unless unresponsive to 4 wk of conservative care or if inflammatory or infectious etiology suspected [B]** AP and lateral foot views **Special investigations** [D]	• MRI useful in differential diagnosis of forefoot pain such as stress fracture, metatarsophalangeal synovitis, and intermetatarsal bursitis[184,201]
C1. Metatarsal bursitis Possible causes: • MTP overstrain and repetitive trauma • Infection • RA • seronegative spondyloarthropathy • gout	**Radiographs not routinely indicated unless unresponsive to 4 wk of conservative care: or if inflammatory or infectious etiology suspected [GPP]** AP and lateral foot views **Special investigations** [GPP]	• MRI useful in differential diagnosis of forefoot pain[201]
C2. Morton neuroma[182] Clinical features: • Most commonly found in the 3–4 web space • Differential diagnosis from metatarsophalangeal arthritis may be difficult • Pain hyperesthesia or paresthesia radiation to the toes • Positive forefoot neuroma squeeze test	**Radiographs indicated** [C] AP, lateral, with or without oblique **Special investigations** [D]	Local anesthetic may be required to differentiate from MTP arthritis • MRI: high sensitivity (0.87; with specificity of 100%) for demonstration of Morton neuroma[58,202] • MRI also useful in differential diagnosis of forefoot pain[201]
C3. Stress (fatigue or insufficiency) fracture[43,203,204] High-risk patients: (a) Athletes: • Running • Dancing • Walking • Other weight-bearing sports (b) Middle-aged or elderly patients: • Weight-bearing activities • Long-term corticosteroid Clinical features: Pain and tenderness in the: • First, second and third metatarsal • Calcaneus • Medial sesamoid • Navicular	**Radiographs indicated** [D] AP and lateral foot views with or without medial oblique specific to the area of complaint **Special investigations** [C]	If radiograph is inconclusive, re-radiograph after 6 wk of restricted use before proceeding to advanced imaging • High-field MRI with fat suppression or inversion recovery protocol. As sensitive as NM (100% sensitive)[43,205] • CT still uncertain[43]; some centers use US
C4. Osteonecrosis of the metatarsal head (Freiberg infraction)[6] Clinical features[182]: • Adolescent patient • Pain	**Radiographs indicated:** [C] AP, lateral, with or without medial oblique of the foot	Radiographic findings (metatarsal head): • Increased density • Flattening, collapse • Cystic changes • Widening of MTP joint

Table 3 (*continued*)

Patient presentation	Recommendations	Comments
• Tenderness • Swelling • Limitation of movement at metatarsal head • Second or third head most commonly affected	**Special investigations** [C]	• MRI modality of choice to evaluate bone marrow changes in early stages
C5. Hallux rigidus and hallux valgus (first MTP joint) Both very common foot disorders resulting in significant morbidity. Possible cause includes DJD, hallux fracture, and fibrous dysplasia.[206–208] Differential diagnosis: • Gout • CPPD • Hydroxyapatite	**Radiographs not routinely indicated unless unresponsive to 4 wk of conservative care [D]** Lateral view most useful for dorsal osteophyte on the metatarsal head and possible osseous fragments[209] **Additional view**[210]: Weight-bearing series to quantify degree of valgus deformity	Radiographs, if obtained, are usually for assessment pre- and post-bunion surgery.[43] Chronic tophaceous gout characterized by extra- and intra-articular erosions, often causing Martel's hook (overhanging margin of bone erosion).[165] Degree of valgus deformity may influence management (orthotics or surgery)
C6. Sesamoiditis[211] Painful inflammatory condition caused by repetitive injury; reactive tendinitis, synovitis, or bursitis common	**Radiographs not routinely indicated unless unresponsive to 4 wk of conservative care:** [D] **Additional view:** Lateromedial and tangential views for sesamoid bones **Special investigations** [GPP]	Possible complications in physically active young and middle age: • Avascular necrosis • Nonunion fracture • Hypoplasia • Osteochondrosis • MRI to differentiate from turf toe

See Bálint et al[165] for additional reading on ankle and foot disorders, and Bucholz and Heckman[212] for fractures in adults.

In this regard, the need to confirm pathology, to follow the evolution of a pathology possibly affecting therapy, or to identify a clinically suspected contraindication to manipulative therapy are the best-documented reasons. The benefits of all diagnostic studies must outweigh the risks and the inherent costs to the patient.[9,31-39]

Uppercase letters enclosed by brackets in both tables and the appendices represent the grading for each recommendation according to SPREAD, while considering the level of evidence (LOE) of studies reviewed during the literature review of Phase 2. Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jmpt.2007.10.003 and in tables DI-D3 in Appendix D of Reference 2.

Tables 1-3 list the patient presentations, recommendations, and comments regarding diagnostic imaging for lower extremity disorders. A list of abbreviations and glossary of terms used in the recommendations are in Appendix A. Appendix B provides a summary of the recommendations. General indications for advanced imaging in extremity disorders are presented in Appendix C. Typical effective ionized radiation dose for common imaging procedures are listed in Appendix D. Further recommended reading pertaining to magnetic resonance imaging of the lower extremity is offered in Appendix E.

Practical Applications

- History taking and physical examination should be used to exclude red flags and serious injuries (fracture and/or dislocation).
- Physical examination is important for neurologic screening.
- These guidelines may assist with diagnostic triage (extremity pain with or without restriction of activity of daily living or presence of red flags).
- Radiographs are not initially indicated for non specific hip, knee, ankle and foot pain.
- Consider conventional radiography after blunt trauma, and if there is no improvement after 4 weeks of conservative care or increasing disability
- Consider conventional radiography and specialized imaging in the presence of red flags.

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Appendix A. List of Abbreviations and Glossary for Lower Extremity Disorders

ACL: anterior cruciate ligament
AP: Anteroposterior
AS: ankylosing spondylitis
Osteonecrosis: avascular necrosis
CPPD: calcium pyrophosphate dihydrate crystal deposition disease
CNS: central nervous system
CT: computed tomography
DJD: degenerative joint disease
LOE: level of evidence
MC: most common
MCP joint: metacarpophalangeal joint
MTP joint: metatarsophalangeal joint
MRA: magnetic resonance arthrography
MRI: magnetic resonance imaging
NM: nuclear medicine (bone scan)
OAR: Ottawa ankle and foot rules
OKR: Ottawa knee rules
PA: posteroanterior
PF: plantar fasciitis
PIP: Proximal interphalangeal joint
ROM: range of motion
RA: rheumatoid arthritis
Tendinosis: degeneration of tendons and of tendon muscle attachments
US: ultrasound
X-ray: plain film radiograph
YOA: years of age
>: greater than
≥: equal or greater than
Ψ: psychology/psychiatry

Appendix B. Summary of Recommendations

Table B1. *Summary of recommendations—adult hip disorders*

Patient presentation	Recommendations
Adult patients with full or limited movement and nontraumatic hip pain of <4 wk of duration **Symptoms are often transient.** Physical examination is primarily to discriminate between articular involvement and referred pain. Each age and sex exhibit typical specific hip, pelvis, and proximal thigh problems and diseases.	**Radiographs not initially indicated** [C]
General indications for radiographs include: • Failed conservative treatment • Complex history • History of noninvestigated trauma • Significant unexplained hip pain with no previous films • Loss of mobility in undiagnosed condition. • Acute or subacute onset of intermittent locking • Palpable enlarging mass	**If radiographs are indicated** [B] AP pelvis and AP frog leg views **Special investigations** [C] MRI is the procedure of choice to exclude osteonecrosis, marrow and joint disease including infection
Specific clinical diagnoses	*Consult specific clinical diagnoses and related patient presentations for additional help in decision making.*
1. Strain, tendinitis or tendinosis Clinical features: • Pain aggravated by activity, resistance testing, and with length-tension evaluation (muscle stretch) • ''Snapping hip'' usually results from iliopsoas tendinitis (internal) or iliotibial band (external) involving both the bursa and tendon. • Suspect adductor muscle strains with medial or anterior thigh pain aggravated by passive abduction or resisted adduction	**Radiographs indicated in suspected osseous avulsion fracture** [D] AP pelvis and AP frog leg views **Special investigations** [D] • MRI for soft tissue involvement (edema, hemorrhage, frank disruption) and bony abnormality • US may demonstrate site and amount of tissue disruption.
2. Piriformis syndrome Clinical features: • Dull posterior hip pain radiating down the leg • May mimic discogenic radicular pain and facet joint referred pain	**Radiographs not initially indicated** [D] **Special investigations [D]** • MRI if unresponsive to care to assess muscle asymmetry and sciatic nerve hyperintensity at the sciatic notch.

Table B1 (*continued*)

Patient presentation	Recommendations
• Limping • Pain aggravated by active external rotation, passive internal rotation, or palpation of sciatic notch.	• MRI or US may reveal bursitis.
3. Nontraumatic trochanteric and iliopsoas bursitis Clinical features: • Localized tenderness and pain • Moderate perceived weakness on resistive testing and length-tension evaluation (whereas true weakness may suggest abnormality such as avulsion of underlying muscle)	Radiographs not initially indicated [D] **Special investigations [D]** • MRI useful in chronic or recurrent bursitis and is most accurate for iliopsoas bursitis • US is a cost-effective, easy-to-perform, and fast alternative. However, it fails to demonstrate iliopsoas bursitis in about 40% of cases.
4. Osteoporotic hip fractures Clinical features: • Patients typically aged >65 y • Often after a fall • Unable to walk • May exhibit shortening and external rotation of the affected limb and localized hip pain Occasionally: • Able to walk • Nonspecific leg discomfort • No obvious shortening or malrotation deformity	**Radiographs indicated** [C] AP spot and AP pelvis view **Special investigations [D]** If radiographs negative but clinically suspected, consider MRI, CT, or NM. • Dual-energy x-ray absorptiometry recommended
5. Septic arthritis of the hip Clinical features: • Significant pain on movement and weight bearing • Malaise • Fever	**Radiographs indicated [C]** AP spot and AP frog leg views **Special investigations** [D] • MRI is the imaging modality of choice for infection. • Joint aspiration or surgery • NM very sensitive but not specific for suspected septic arthritis and osteomyelitis
Consider obtaining radiographs in adult patients with chronic hip pain unresponsive to 4 wk of conservative care or if one of the following conditions is suspected: 1. Congenital or developmental abnormalities 2. OA (limited ROM) 3. Inflammatory arthritis 4. Osteonecrosis 5. Tumors 6. Stress fractures or undisplaced fractures	**Radiographs indicated** [D] AP spot and AP frog leg **Additional views:** AP pelvis in suspicion of congenital abnormality, osteonecrosis, inflammatory arthritis **Special investigations** [D] • Unenhanced MRI done first (highly sensitive) • MR arthrography • Anesthesia injection • Examination under local anesthesia • Diagnostic arthroscopy
Specific clinical diagnoses	
1. Congenital/developmental abnormalities Plain film radiograph as primary investigation for chronic hip pain, "knife sharp" groin pain, painful giving way, locking and painful clunk, and painful apprehension and impingement tests includes: ***(a) Acetabular dysplasia*** Exclude in athlete aged <30 y with chronic hip pain. ***(b) Labral tear and femoroacetabular impingement*** Clinical features: • "Knife sharp" groin pain • Painful giving way syndrome • Locking • Painful clunk or snapping hip • Painful apprehension tests (forced hyperextension-external rotation in slight	**Radiographs indicated [D]** Standing AP pelvis and recumbent AP false profile view **Additional views:** Abduction view of the hip (to determine eligibility for joint preserving surgery) **Special investigations** [D] • Unenhanced MRI for hip articular cartilage and labrum defects • MRI arthrography has high accuracy (90%) and diagnostic arthroscopy with labral resection

(*continued on next page*)

Table B1 (*continued*)

Patient presentation	Recommendations
abduction) • Painful impingement test (forced flexion adduction)	
2. Osteoarthritis (OA) Clinical features: • Age ≥40 y • Hip pain only with possible protective limp • Activity-induced symptoms • Improvement with rest • Stiffness: in the morning or with periods of inactivity • May be bilateral • Significant decrease in pain with weight loss and exercise in patient aged >60 y **Test for ROM:** • Restricted and painful internal rotation (LOE III) • 3 Planes ROM limitations less sensitive but more specific	**Radiographs indicated** [B] AP spot and AP frog leg views
3. Inflammatory arthritis (seronegative and seropositive) Unrelenting morning stiffness >30 min, pain at rest, pain or stiffness better with light activity, polyarticular involvement, warmth, effusion, diffuse tenderness, decreased ROM; fever/chills or other systemic symptoms, responsive to NSAID/steroid, flexion and adduction contracture in long-standing arthritis. RA diagnostic criteria (≥4 of 7 required): • Morning joint stiffness> 1 hour • Arthritis involving ≥3 joints for at least 6 wk • Hand arthritis (wrist, MCP, PIP) • Symmetric arthritis • Rheumatoid nodules • Serum Rh factor • Radiographic changes	**Radiographs indicated** [D] AP spot and AP frog leg views AP pelvis may also be warranted as initial study to assess both hips **Special investigations** [D] MRI highly sensitive and often more specific than US. Detection of synovial pannus, erosions, cartilage loss, small subchondral cysts, and marrow edema distribution US may show effusion and osseous erosions
4. Osteonecrosis (avascular necrosis) Clinical features: • Most common in those aged <50 y • M:F = 8:1; in younger patients, M:F = 4.2:1 • Progressive groin pain that may refer to the knee • Early stages: normal ROM • Advanced stages: limitation of extension, internal rotation and abduction; limping and atrophy.	**Radiographs indicated** [B] AP spot and AP frog leg views Consider AP pelvis as initial examination as condition may be bilateral **Special investigations** [B] MRI useful when radiographs are normal, especially in high-risk patients; also NM and CT (when MRI unavailable)
5. Tumors and metastatic lesions Variable clinical features; spontaneous pathologic fracture is often first sign of metastasis from breast, lung, or prostate cancer.	**Radiographs indicated** [D] AP spot and AP frog leg views **Special investigations** [D] NM, CT, MRI
6. Stress (fatigue or insufficiency) fractures Exertional anterior hip pain, especially after an increase in training regimen. Chronic repetitive overloads, typically in athletes or reduced mechanical bone properties (athletic amenorrhea, osteoporosis, corticosteroid use)	Radiographs indicated [D] AP spot and AP frog leg views If radiograph is inconclusive, re-radiograph after 10-14 d of restricted use before going to advanced imaging **Special investigations** [D] Bone scan, MRI, or CT in suspected occult, osteoporotic, or stress fractures
Adult patients with significant hip trauma Delay in recognition and reduction of acute dislocations, fractures, and fracture-dislocation of hip leads to preventable complications and morbidity (LOE III).	**Radiographs indicated** [C]

Table B1 (*continued*)

Patient presentation	Recommendations
	AP pelvis, AP centered of hip, right and left obliques of the pelvis, and true lateral views **Special investigations** [C] MRI for patients with significant hip pain after injury, especially when unable to bear weight; also to exclude occult fracture and possible labral tear

Table B2. *Summary of recommendations—adult knee disorders*

Patient presentation	Recommendations
Adult patients with nontraumatic knee pain of <4 wk of duration • Symptoms frequently arise from soft tissues not seen on radiographs • Physical examination should include lower back, pelvis, hip, foot, and ankle as pain may be referred	**Radiographs not initially indicated** [C]
General indications for knee radiographs include: • History of noninvestigated trauma (with signs from the OKR—see below) • Complex history • Significant unexplained effusion with no previous films • Loss of mobility in undiagnosed condition. • Acute/subacute onset • Intermittent locking • Unrelieved by 4 wk of conservative care • Palpable enlarging mass	**When radiographs are indicated or unless otherwise specified [C]** • Standing AP views for joint space integrity • Consider recumbent AP views if osseous detail is important • Lateral view • Tunnel (intercondylar) view **Special investigations** [C] • US useful to visualize superficial soft tissue structures (tendons, collateral ligament bursae) • MRI best for internal derangements and can often prevent unnecessary knee arthroscopy
Specific clinical diagnoses **1. Osteoarthritis (OA)** The clinical criteria for OA of the knee are: History: • Age> 50 y • Morning joint stiffness < 30 min Physical examination: • Crepitation • Bony tenderness • Bony enlargement • No palpable warmth Other characteristics include: long-standing pain, no extra-articular symptoms; aggravated by weight bearing, climbing stairs, exercise; nonresponsive to NSAID or corticosteroid medication; relieved with rest; deformity or fixed contracture, joint effusion; insidious onset.	Radiographs indicated if unrelieved by 4 wk of conservative care [B] AP, lateral, and intercondylar views if radiographs are indicated **Additional views:** 45° (oblique) views if signs and symptoms do not correlate with standard views **Special investigations** [B] US or MRI indicated if significant effusion and/or loss of joint space
2. Inflammatory arthritis (seronegative and seropositive) Diagnosis of inflammatory arthritis of the knee is primarily based on history and physical examination: • Unrelenting morning stiffness< 30 min • Pain at rest • Pain or stiffness better with light activity (during remission) • Polyarticular involvement, especially the hands • Palpable warmth • Joint effusion • Decreased ROM • Fever/chills or other systemic symptoms • Responsive to NSAID or corticosteroid medication • Flexion and adduction contracture in long-standing arthritis • See also hip section for RA diagnostic criteria	**Radiographs indicated** [D] Consider bilateral AP standing views **Special investigations** [C] • US and MRI may aid in staging and as indicator of disease progression • Knee aspiration if positive for effusion
3. Bursitis/tendinitis/strain/tendinosis Clinical features:	Radiographs not routinely indicated unless [D] • Unrelieved by 4 wk of conservative care

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Table B2 (*continued*)

Patient presentation	Recommendations
• Related to or aggravated by activity • Relieved or diminished symptoms at rest • Point tenderness • Localized swelling (extra-articular)	• Suspected avulsion fracture • Underlying arthropathy **Special investigations** [D] • MRI • Puncture of a popliteal cyst and corticosteroid injection can be done under US guidance.
4. Anterior knee pain Clinical features: • Insidious onset • Aggravated with steps/incline/rising from chair • Stiffness with rest or gliding • Pseudolocking or giving way • Tender patellar facets • Positive apprehension tests • Crepitation • Abnormal Q angle Clinical tests for the diagnosis of chondromalacia patella have low sensitivity, specificity, predictive values, and accuracy compared with tests for arthroscopy.	**Radiographs indicated if [C]** • Unrelieved by 4 wk of conservative care • Suspected fracture • Underlying arthropathy **Additional views:** • Tangential patellar views to evaluate for chondromalacia, patellar tilt or subluxation • Stress radiographs to evaluate for patellofemoral instability (stress view: valgus and internal rotation at 45° of knee flexion)[91] **Special investigations** [C] • High-field MRI for chondromalacia and synovial plicae • Contrast CT arthrography if MRI unavailable
5. Internal joint derangement Clinical features: History • Acute or subacute onset • Mechanism of injury • Intermittent locking and/or giving way • Crepitation, snapping, and popping • Worse with activity • Improved with rest (The accuracy of the clinical history in patients with suspected torn ligament or meniscus is unknown.) Physical examination: • Joint line tenderness • Swelling and joint effusion • Loss of ROM Meniscal tear: joint line tenderness, McMuray, and Ege's test (weight-bearing McMurray test) Ligamentous tear: Lachman maneuver, pivot test, and the Anterior Drawer Test	**Radiographs indicated if unrelieved by 4 wk of conservative care** [B] Standard AP, lateral views if necessary after 4 wk **Additional views:** tunnel, standing lateral, standing oblique **Special investigations** [C] If diagnosis not well established from Hx, examination and radiographs or in the absence of clinical improvement • MRI is gold standard for internal knee derangements such as meniscal and ligamentous injuries • Spiral CT arthrography if MRI unavailable
Adult with acute knee injury but negative findings for the OKR indicates that a fracture is very unlikely. Consider radiographs only of patients excluded from the OKR: • <18 YOA • Pregnancy • Isolated skin injury • Referred with outside films • 7 d since injury • Multiple injuries • Altered level of consciousness • Paraplegic	**Radiographs not routinely indicated** [B] Patient should be advised to return for follow-up if their pain has not improved in 7 d
Adult with acute knee injury and positive findings for the OKR Radiographs indicated in the presence of one or more of the OKR criteria [A] Radiographs required only in the presence of postinjury knee pain and any one of the following findings: • ≥55 YOA • Isolated tenderness at the head of the fibula or patella • Inability to flex knee >90° • Inability to walk 4 weight-bearing steps both immediately and at presentation	AP supine and lateral views **Additional views:** bilateral obliques, tunnel, and tangential views **Special investigations** [C] • Valgus stress radiographs under general anesthesia • MRI is the modality of choice for initial investigation of knee trauma.

Table B2 (*continued*)

Patient presentation	Recommendations
Radiographs should also be obtained in the presence of obvious deformity or mass.	• CT, US, and angiogram may be needed for additional information.

Table B3. *Summary of recommendations—adult ankle and foot disorders*

Patient presentation	Recommendations
Adult with acute ankle and foot injury but negative findings on the OAR Consider radiographs only of patients excluded from the OAR: • Multiple injuries • Isolated skin injury • 10 d since injury • Obvious deformity of ankle or foot • Altered sensorium: cognitive or sensory impairment (neurologic deficit), head trauma, intoxicated	**Radiographs not routinely indicated** [B]
Adult with acute ankle and foot injury and positive findings on the OAR **(a) Ankle (positive OAR)** Radiographs required only if there is pain in the malleolar zone and any of these findings: • Bone tenderness of distal fibula along posterior edge or tip of lateral malleolus (distal 6cm) • Bone tenderness of distal tibia along posterior edge or tip of medial malleolus (distal 6 cm) • Inability to bear weight both immediately and in clinic Also consider taking ankle radiographs in: • Older patients with malleolar tenderness and pronounced soft tissue edema. • Presence of positive OAR foot findings **(b) Foot (positive OAR)** Radiograph required only if there is pain in the midfoot zone and any of these findings: • Bone tenderness of base of fifth metatarsal • Bone tenderness of navicular bone • Unable to bear weight both immediately and in clinic	**Ankle radiographs indicated** [B] AP ankle, 20° medial oblique (mortise views) and lateral (include base of fifth metatarsal) **Additional views** [D]: Stress radiographs after fibular fracture helpful pre-operatively to determine deltoid ligament status in orthopedic setting. **Special investigations** [D] • MRI or CT appropriate in presence of significant pain and disability and negative radiographs • Fluoroscopic stress examination under anesthesia to assess ankle instability • NM for persisting symptoms to exclude stress fracture **Foot radiographs indicated** [B] When feasible, weight-bearing foot AP, lateral, medial oblique views Comparison views (normal foot) may be helpful. **Additional view:** tangential view of calcaneus for heel trauma cases
Adult with acute toe injury Consider obtaining foot radiographs in presence of significant metatarsal pain (see OAR-Foot)	**Radiographs indicated** [GPP]: AP, oblique, and lateral views limited to the toes
Adult with chronic ankle and tarsal pain Specific indications for radiographs include: • Suspected osteochondral lesion/stress fracture • Suspected tendinopathy with possible inflammatory arthritis • Possible ankle instability. Single-leg jump test as clinical indicator of functional instability • Noninvestigated chronic ankle and tarsal pain • Multiple sites of degenerative joint disease as visualized on radiographs • Possible operative candidate	**Radiographs indicated** [D] AP ankle, lateral, medial oblique (mortise) views (Medial oblique view helps evaluate the talocalcaneal relationship and lateral malleolus.) **Additional view:** Stress radiographs may be considered, but little agreement exists as to which technique. **Special investigations** [D] MRI is the gold standard for musculoskeletal assessment if radiography is positive or if unrelieved by 4 wk of conservative care. • Contrast-enhanced, fat-suppressed, 3D, fast-gradient MRI may be useful in diagnosing synovitis and soft tissue impingement.
Specific clinical diagnoses	
1. Impingement syndromes Findings most strongly associated with abnormality at arthroscopy: • Anterolateral tenderness • Swelling • Pain on single-leg squatting • Pain on ankle dorsiflexion and eversion	**Radiographs indicated [D]** AP ankle, lateral and mortise views **Special investigations** [D] For all suspected impingement syndromes with positive radiographs or unrelieved by 4 wk of conservative care: • Contrast-enhanced, fat-suppressed, 3D, fast-gradient MRI may be indicated depending on pain severity and disability.

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Table B3 (*continued*)

Patient presentation	Recommendations
(a) Anterolateral impingement Clinical features: • Mechanism: inversion injury • Pain and localized tenderness in region of anteroinferior tibiofibular and/or anterior talofibular ligament • Positive impingement sign	**Radiographs indicated** [D] AP, lateral, and mortise ankle views **Additional view:** [D] Stress radiographs may be considered.
(b) Anterior impingement Clinical features: • Mechanism: supination or repeated dorsiflexion injury • Anterior pain • Painful and restricted dorsiflexion	**Radiographs indicated** [D] AP, lateral, and mortise ankle views
(c) Anteromedial impingement Clinical features: • Mechanism: inversion injury or ankle/talar fracture • Anteromedial pain and tenderness • Swelling • Pain and restriction on dorsiflexion and supination	**Radiographs indicated** [D] AP, lateral, and mortise ankle views
(d) Posterior impingement Clinical features: • Mechanism: impingement of os trigonum between talus and posterior tibia • Common in ballet dancers • Pain elicited with full weight-bearing in maximum plantar flexion, especially when os trigonum is present. • Tenderness behind lateral malleolus	**Radiographs indicated** [D] AP, lateral, and mortise ankle views **Special investigations** [D] MRI for os trigonum syndrome • Pain with passive plantar flexion
2. Peroneal tendinosis Clinical features: • Lateral hindfoot pain • Cavovalgus foot deformity • Frequently affected in RA	**Radiographs not routinely indicated** [D] Unless unrelieved by 4 wk of conservative care or patient has a suspected inflammatory arthritis **Special investigations** [D] MRI or US if there are signs of popping or clicking with foot eversion
3. Lateral premalleolar bursitis Clinical features: • Adventitious bursa develops after prolonged sitting with inverted and plantar flexed feet	**Radiographs not routinely indicated** [GPP] **Special investigations** [GPP] US if unrelieved by 4 wk of conservative care
4. Tarsal tunnel syndrome Clinical features: • Tingling pain and burning over the sole of the foot after prolonged standing or walking • Worse at night in some • Positive Tinel sign • Positive nerve compression test • 2-Point discrimination • Hypoesthesia on sole of foot • Rare weakness of toe flexion	**Radiographs not routinely indicated** [D] **Special investigations** [D] • US or MRI for nerve and other soft tissue visualization • CT for bony abnormalities • Sensory conduction velocity and distal motor latency useful for diagnosis and treatment progression
Adult with chronic foot pain	**Radiographs generally indicated** [C] Non–weight-bearing AP, lateral, medial, and lateral oblique views **Additional views:** • Lateral views for toes • Axial and lateromedial tangential views for sesamoid bones **Special investigations** [D] • NM, MRI, US, arthrography may be useful • Laboratory investigations (blood and synovial fluid) recommended
A. Hindfoot-Heel pain	**Radiographs indicated** [D] AP, lateral, and medial oblique views of the foot Additional views: tangential view of the calcaneus and lateral calcaneus view

Table B3 (*continued*)

Patient presentation	Recommendations
	Special investigations [D] • MRI if unrelieved by 4 wk of conservative care or before referral for medical care or to podiatrist • Achilles enthesopathy: power Doppler sonography may show neovascularization, which may be the cause of pain.
Specific clinical diagnoses	
A1. Plantar fasciitis (PF) and calcaneal enthesosphyte (spur) Clinical features: • PF is one of the most common soft tissue foot disorders • Hyperesthesia over the plantar fascia • Risk factors: ○ Decreased ankle dorsiflexion (≤0°) ○ Being on their feet most of working day ○ Obesity (body mass index >30 kg/m^2)	**Radiographs not routinely indicated except in young athlete [B]** AP, lateral, and oblique views **Special investigations** [D] • US may be initial step for advanced imaging (readily available, highly sensitive, low-cost, and radiation-free). • Doppler/power US improves US value • US, MRI, and bone scan are more sensitive in showing inflammatory changes and thickening of the plantar aponeurosis in PF
A2. Sinus tarsi syndrome Clinical features: • Mechanism: inversion injury or inflammatory joint diseases • Lateral foot pain • Perceived foot instability • Tenderness of the sinus tarsi	**Radiographs not initially indicated** [D] **Special investigations** [D] MRI if unrelieved by 4 wk of conservative care: may be helpful for detecting subtle unilateral deformities
B. Midfoot pain (nontraumatic) Midfoot pain usually self-limiting. Differential diagnosis: • RA • Psoriatic arthritis • Reactive arthritis (Reiter disease) • Diabetic neuroarthropathy/Charcot joints • Gout • Diabetic infection	**Radiographs indicated if unrelieved by 4 wk of conservative care or in suspected inflammatory arthritis** [D] AP, medial oblique, and lateral views of the foot **Additional views:** weight-bearing ankle series may be useful **Special investigations if radiography is positive or if unrelieved by 4 wk of conservative care** [GPP] CT or MRI warranted in suspected or proven disease, but negative/equivocal radiographs
Specific clinical diagnoses	
B1. Acquired flat foot with posterior tibial tendon dysfunction/rupture Clinical features: • Medial ankle/foot pain initially • May lead to disabling weight bearing symptoms • Talonavicular subluxation • Difficulty or inability to perform single-limb heel rise • Weak resisted inversion of fully flexed foot	**Radiographs indicated if unrelieved by 4 wk of conservative care or in suspected inflammatory arthritis** [D] AP, medial oblique, and lateral foot radiographs **Additional views:** weight-bearing ankle series may be useful **Special investigations** [D] • MRI better at differential diagnosis of medial ankle/foot pain • US may be useful
B2. Navicular tuberosity pain and tenderness[148] Potential painful normal variants such as accessory navicular bone (4%-21% of the population) have been described. Painful fibro-osseous junction of the accessory bone	Radiographs indicated if unrelieved by 4 wk of conservative care [C] AP, medial oblique, and lateral foot views **Special investigations** [GPP] • MRI to differentiate accessory navicular from an avulsion fracture • NM may be useful to help identify or confirm site of pain.
B3. Complex regional pain syndrome Synonyms: • Reflex sympathetic dystrophy • Sudek's atrophy Clinical features: • Pain	**Radiographs indicated** [D] AP, lateral, and medial oblique views of the foot **Special investigations** [D] • MRI is useful in detecting numerous soft tissue and earlier bone and joint processes that are not depicted or as well characterized with other imaging modalities • 3-Phase NM scan recommended if radiograph is not diagnostic

(*continued on next page*)

Table B3 (*continued*)

Patient presentation	Recommendations
• Tenderness • Swelling • Diminished motor function • Vasomotor and sudomotor instability	
C. Forefoot pain See recommendations for the following specific clinical diagnoses: C1. Metatarsal bursitis C2. Morton neuroma C3. Stress fracture C4. Avascular necrosis (osteonecrosis) C5. Hallux rigidus and hallux valgus C6. Sesamoiditis	**Radiographs not routinely indicated unless unresponsive to 4 wk of conservative care or if inflammatory or infectious etiology suspected** [B] AP and lateral foot views **Special investigations** [D] MRI useful in differential diagnosis of forefoot pain such as stress fracture, metatarsophalangeal synovitis, and intermetatarsal bursitis
C1. Metatarsal bursitis	**Radiographs not routinely indicated unless unresponsive to 4 wk of conservative care, or if inflammatory or infectious etiology suspected** [GPP] AP and lateral foot views **Special investigations** [GPP] MRI useful in differential diagnosis of forefoot pain
C2. Morton neuroma Clinical features: • Most commonly found in the 3-4 web space • Pain hyperesthesia or paresthesia radiation to the toes • Differential diagnosis from MTP arthritis may be difficult • Positive forefoot neuroma squeeze test	**Radiographs indicated** [C] AP, lateral, with or without oblique **Special investigations** [D] MRI
C3. Stress (fatigue or insufficiency) fracture Clinical features: Pain and tenderness present in the: • Second and third metatarsal • calcaneus • First metatarsal • medial sesamoid • Navicular	**Radiographs indicated** [D] AP and lateral foot views with or without medial oblique specific to the area of complaint **Special investigations** [C] • High-field MRI with fat suppression or inversion recovery protocol. As sensitive as NM • CT still uncertain; some centers use US
C4. Osteonecrosis of metatarsal head (Freiberg infraction) Clinical features: • Adolescent patient • Pain • Tenderness • Swelling • Limitation of movement at metatarsal head • Second or third head most commonly affected	**Radiographs indicated** [C] AP, lateral, with or without medial oblique of the foot **Special investigations** [C] MRI modality of choice to evaluate bone marrow changes in early stages
C5. Hallux rigidus and hallux valgus (first metatarsophalangeal joint)	**Radiographs not routinely indicated unless unresponsive to 4 wk of conservative care** [D] Lateral view most useful for dorsal osteophyte on the metatarsal head and possible osseous fragments **Additional view:** Weight-bearing series to quantify degree of valgus deformity
C6. Sesamoiditis Painful inflammatory condition caused by repetitive injury; reactive tendinitis, synovitis, or bursitis common	**Radiographs not routinely indicated unless unresponsive to 4 wk of conservative care** [D] **Additional view:** Lateromedial and tangenital views for sesamoid bones **Special investigations** [GPP] MRI to differentiate from turf toe

Appendix C. General Indications for Advanced Imaging in Extremity Disorders

Indications	MRI	CT	NM	US
Evaluation of neoplasm detected on conventional radiographs	++	+		
Determining skeletal distribution of neoplasms or other multifocal skeletal disease			++	
Internal joint derangements	++	+		+
Inflammatory arthritis	+	+	+	++
Evaluation of soft tissue injury, tendon pathology, calcified bursitis	++			++
Osteomyelitis	++	+	++	
Fluid collections or infections in joints or extra-articular soft tissues; unexplained soft tissue mass	++			++
Osteonecrosis	++	+	+	
Complicated fractures	+	++		
Suspected stress, occult fracture	+	+	++	
Complicated disease processes or findings unexplained by more conservative tests	+	+		

++, First choice; +, second choice (must be determined on a case-by-case basis)[a,b,c]

[a]Adapted with permission from Peterson C. Canadian Guidelines for Imaging (2002, unpublished data).

[b]Santiago RC, Gimenez CR, McCarthy K. Imaging of osteomyelitis and musculoskeletal soft tissue infections: current concepts. *Rheum Dis Clin North Am* 2003;29(1):89-109.

[c]Cardinal E, Bureau NJ, Aubin B, Chhem RK. Role of ultrasound in musculoskeletal infections. *Radiol Clin North Am*. 2001;39(2):191-201.

Appendix D. Typical Effective Ionized Radiation Dose for Common Imaging Procedures*

Class	Typical effective dose (mSv)	Examples
0	0	Ultrasound, magnetic resonance imaging
I	<1	Radiograph: cervical and thoracic spine, extremities, pelvis, and lungs
II	1-5	Lumbar spine radiograph, Nuclear medicine, cervical spine CT
III	5-10	Chest and abdomen CT

***Classification of the typical effective dose of ionizing radiation from common imaging procedures.** Adapted from European Commission. Radiation protection 118. Referral guidelines for imaging in conjunction with the UK Royal College of Radiologists; Italy 2001. p 21.

Appendix E. Additional Reading Recommended on MRI

- Grenier JM, Wessely MA. Hip and pelvis MRI. Part 1: A basic overview. *Clin Chiropr* 2006; 9:92-8.
- Grenier JM, Wessely MA. Hip and pelvis MRI. Part 2: Common pathological conditions of the pelvis and hip. *Clin Chiropr* 2006;9:150-9.
- Grenier JM, Green NA, Wessely MA. Knee MRI. Part I: basic overview. *Clin Chiropr* 2004;7:84-9
- Grenier JM, Wessely MA. Knee MRI. Part II: MR imaging of common internal derangements affecting the knee. *Clin Chiropr* 2004;7:131-40.
- Wessely MA. MR imaging of the ankle and foot—a review of normal imaging appearance with an illustration of common disorders. *Clin Chiropr* 2007;10:101-11.

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