

Canadian Association of Radiologists Musculoskeletal System Diagnostic Imaging Referral Guideline

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Abstract

The Canadian Association of Radiologists (CAR) Musculoskeletal System Expert Panel consists of musculoskeletal radiologists, a family physician, a sports and exercise medicine physician, emergency medicine physicians, a patient advisor, and an epidemiologist/guideline methodologist. After developing a list of 25 musculoskeletal clinical/diagnostic scenarios, a systematic rapid scoping review was undertaken to identify systematically produced referral guidelines that provide recommendations for 1 or more of these clinical/diagnostic scenarios. Recommendations from 41 guidelines (50 publications) and contextualization criteria in the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) for guidelines framework were used to develop 124 recommendation statements across the 25 scenarios related to the evaluation of the musculoskeletal system. This guideline presents the methods of development and the recommendations for imaging in the context of musculoskeletal pain, infection, tumors, arthropathies, metabolic bone disease, stress injuries, orthopedic hardware, avascular necrosis/bone infarction, and complex regional pain syndrome.

Résumé

Le groupe d'experts du système musculo-squelettique de l'Association canadienne des radiologistes (CAR) est constitué de radiologistes, d'un médecin de famille, d'un urgentologue, d'un médecin du sport, d'un représentant des patients et d'un épidémiologiste spécialisé en méthodologie de l'élaboration de lignes directrices. Après avoir élaboré une liste de 25 scénarios cliniques/diagnostiques dans le domaine musculo-squelettique, une revue systématique rapide de délimitation du problème a été entreprise pour identifier les lignes directrices de référence produites systématiquement qui fournissent des recommandations pour un ou plusieurs de ces scénarios cliniques/diagnostiques. Des recommandations de 41 lignes directrices (50 publications) et critères de contextualisation dans le cadre GRADE (notation des recommandations, analyses, développements et évaluations) pour la structure des lignes directrices ont été utilisés pour élaborer 124 énoncés de recommandations couvrant les 25 scénarios liés à l'évaluation du système musculo-squelettique. Les présentes lignes directrices présentent les méthodes d'élaboration et les recommandations pour l'imagerie dans le cadre des douleurs musculo-squelettiques, des tumeurs, des arthropathies, des maladies métaboliques de l'os, des lésions de fatigue, du matériel orthopédique, de la nécrose avasculaire et de l'infarctus osseux, et du syndrome douloureux régional complexe.

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Introduction

Beginning in May 2021, an Expert Panel (EP) comprised of musculoskeletal radiologists, a family physician, a sports and exercise medicine physician, emergency medicine physicians, a patient advisor, and an epidemiologist/guideline methodologist met to develop a new set of recommendations specific to referral pathways for the musculoskeletal system. Through discussions (via virtual meetings) and offline communication, the EP developed a list of 25 clinical/diagnostic scenarios to be covered by this guideline. These recommendations are intended primarily for referring clinicians (eg, family physicians, emergency physicians, advanced care practitioners, other allied musculoskeletal specialties); however, they may also be used by radiologists, patients, and patient representatives.

Our methods describing the guideline development process, including the rapid scoping review to identify the evidence base, have been published in *CMAJ Open*¹ and an editorial to this series of guideline publications is available in *CARJ*.² The application of well-established scoping review and rapid review guidance (JBI,³ Cochrane Handbook,⁴ Cochrane Rapid Review Methods Group⁵) and guideline methodology (ie, Grading of Recommendations Assessment, Development, and Evaluation or GRADE^{6,7}) were used to identify the evidence-base and to guide the Expert Panel in determining the strength and direction of the recommendations for each clinical scenario (Table 1). The quality of conduct and reporting of the included guidelines identified in the scoping review were evaluated with the AGREE-II checklist,⁸ using a modified scoring system. In

instances where guidelines were lacking, expert consensus was used to develop the recommendation. Contextualization to the Canadian health care system was discussed for each recommendation, with discussion around the factors found in the Evidence to Decision framework in GRADE for guidelines (eg, balance of desirable and undesirable outcomes, values and preferences, resources implications).⁷

A systematic search for guidelines (with an a priori defined inclusion criteria) was run in Medline and Embase on July 22nd, 2021. The search was limited to publications on 2016 onward (Supplementary file Appendix 1). Supplemental searching included the following national radiology and/or guideline groups: the American College of Radiology (ACR), the National Institute for Health and Care Excellence (NICE), and the Royal College of Radiologists (RCR) 8th Edition (2017). Recommendations for each clinical scenario were formulated over 7 virtual meetings from September 2021 to February 2022. External review and feedback were obtained from radiologists, emergency physicians, a family physician, a nurse practitioner, an orthopaedic surgeon, a rheumatologist, and a nuclear medicine specialist. The full guideline can be found on the CAR website (www.car.ca).

Results

Systematic Scoping Review

A total of 5937 records were identified through the electronic database and 7 additional records were added from the

Table 1. Recommendation Text, Symbol, and Interpretation.

Recommendation	AGAINST	FOR
STRONG	<p>Strong, against “we recommend against” (↓↓)</p> <ul style="list-style-type: none"> - All or almost all informed people would not recommend/choose the course of action and only a small proportion would 	<p>Strong, for “we recommend” (↑↑)</p> <ul style="list-style-type: none"> - All or almost all informed people would recommend/choose the course of action and only a small proportion would not - Request discussion if the intervention is not offered
CONDITIONAL	<p>Conditional, against “we suggest against” (↓)</p> <ul style="list-style-type: none"> - Most informed people would not recommend/choose the course of action, but a substantial number would - This may be conditional upon patient values and preferences, the resources available or the setting in which the intervention will be implemented 	<p>Conditional, for “we suggest” (↑)</p> <ul style="list-style-type: none"> - Most informed people would recommend/choose the course of action, but a substantial number would not - This may be conditional upon patient values and preferences, the resources available or the setting in which the intervention will be implemented

Note. Down arrows are red and Up arrows are green when available in colour.
Created using the guidance provided in Andrews and colleagues.⁶

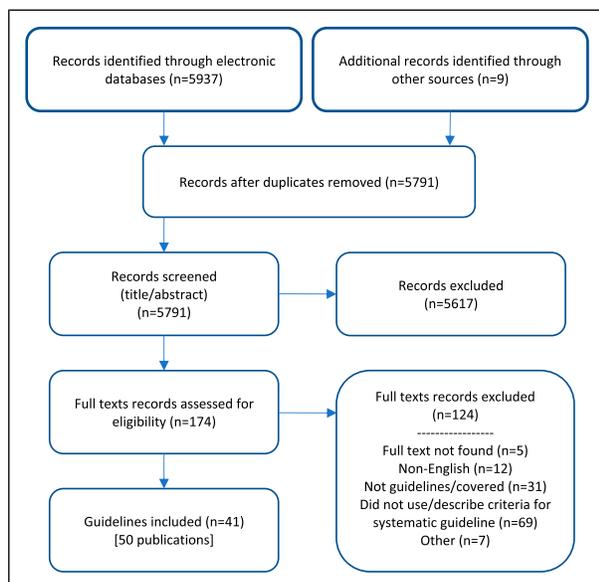


Figure 1. PRISMA flow diagram.

supplemental search. A total of 41 guidelines, plus 9 companion papers, were included (Figure 1). Potentially relevant guidelines published in languages other than English can be found in [Supplementary file Appendix 2](#). A list of excluded records including justifications for exclusion is available upon request. Most guidelines were rated as moderate or high quality, using the modified AGREE-II checklist ([Supplementary file Appendix 3](#)). The number of guidelines included per clinical/diagnostic scenario ranged from zero to 8, with a median of 4 guidelines per clinical scenario.

Recommendations

Additional details of the included guidelines, including which imaging modalities (ie, computed tomography [CT], computed tomography arthrography, dual-energy X-ray absorptiometry [DEXA], fluoroscopy, magnetic resonance arthrography, magnetic resonance imaging [MRI], nuclear medicine [NM], positron emission tomography [PET], radiograph [XR], ultrasound [US]) that were discussed can be found in [Supplementary file Appendix 4](#).

A guideline is intended to guide and not be an absolute rule. Medical care is complex and should be based on evidence, a clinician's expert judgment, the patient's circumstances, values, preferences, and resource availability. Not all imaging modalities are available in all clinical environments, particularly in rural or remote areas of Canada. Decisions about

patient transfer, use of alternative imaging or serial clinical examination and observation can be difficult. Therefore, the expected benefits of recommended imaging, risks of travel, patient preference, and other factors must be considered. The guideline recommendations address choice of imaging modality, not the management of individual patients in contexts where modalities are not available. Imaging should not delay definitive management.

We reviewed relevant recommendations related to the 25 clinical/diagnostic scenarios previously published by radiology and specialty societies, including: the Canadian Association of Radiologists,⁹ the American Academy of Orthopaedic Surgeons,^{10,11} the American College of Physicians (ACP),¹² the American College of Radiology (ACR),¹³⁻³⁰ the Brazilian Society of Rheumatology,³¹ the combined guideline by the European Association of Nuclear Medicine, the European Bone and Joint Infection Society, and the European Society of Radiology,³²⁻³⁴ the European League Against Rheumatism (EULAR),^{35,36} the European Society of Musculoskeletal Radiology,³⁷ the European Society for Medical Oncology,³⁸ the German S-3 (the German Society for Orthopaedics and Traumatology [DGOOC] and the German Societies of Radiology [DRG], of Physical Therapy and Rehabilitation [DGPMR] and Osteology [DVO]),³⁹ the International Consensus on Orthopedic Infections,⁴⁰ the International Hip-related Pain Research Network,⁴¹ the Lisbon Agreement,⁴²⁻⁴⁴ the National Institute for Health and Care Excellence,⁴⁵⁻⁵² the Paget's Association,⁵³ the Royal College of Radiologists (RCR),⁵⁴ the Society for Vascular Surgery in collaboration with the American Podiatric Medical Association and the Society for Vascular Medicine,⁵⁵ the Spanish Society of Rheumatology,⁵⁶ and the United States Preventive Services Task Force (USPSTF).^{57,58}

Although the ACR Appropriateness Criteria® Chronic Elbow Pain⁵⁹ did not meet the inclusion criteria for this guideline, as it was published in 2015, due to the lack of recommendations around other imaging modalities for the elbow pain scenario, it was referenced to provide additional support to the CAR discussions and recommendations.

Recommendations are presented in 3 tables: Soft tissue and bone infection, bone tumour, soft tissue mass, and soft tissue pain (Table 2), Arthropathy, bone pain, metabolic bone disease, stress fracture, and chest wall pain (Table 3), Shoulder, elbow, hand/wrist, MSK pelvis or hip, knee, ankle, foot and orthopedic hardware/arthroplasty pain, avascular necrosis/bone infarction, and complex regional pain syndrome (Table 4).

Table 2. Soft Tissue and Bone Infection, Bone Tumour, Soft Tissue Mass, and Soft Tissue Pain Recommendations.

Clinical/Diagnostic Scenario and Recommendations.

M01. OSTEOMYELITIS, INCLUDING DIABETIC FOOT^{9,13,14,32,33,45,54,55}

1. In adults with suspected osteomyelitis, including the diabetic foot, we recommend **XR** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).
 - ↳ 1.2 If MRI is unavailable or contraindicated, we suggest **CT** (with contrast) or **NM** (bone scan) (↑).^a
2. In adults with suspected osteomyelitis, we recommend **CT** for evaluation of sequestra or for guiding biopsy (↑↑).
3. In adults with suspected osteomyelitis, where MRI or CT were not performed, we suggest **US** to evaluate for superficial fluid collections (↑).

M02. SEPTIC ARTHRITIS^{13,37}

1. In adults with suspected septic arthritis, we recommend **XR** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).
 - ↳ 1.2 If MRI is unavailable or contraindicated, we suggest **CT** (with contrast) (↑).
2. In adults with suspected septic arthritis, where MRI or CT were not performed, we suggest **US** to evaluate for effusion or juxta-articular fluid collections (↑).
3. In adults with suspected septic arthritis, we suggest **US** or **fluoroscopy** to facilitate arthrocentesis, immediately after XR, if bedside arthrocentesis is not feasible (EP consensus).

M03. SOFT TISSUE INFECTION, INCLUDING NECROTIZING FASCIITIS¹³

1. In adults with suspected soft tissue infection, including necrotizing fasciitis, we recommend **XR** as the initial imaging modality (↑↑).^b
2. In adults with suspected deep or aggressive soft tissue infection, we recommend **MRI** as the next imaging modality (↑↑).
 - ↳ 2.1 If MRI is unavailable or contraindicated, we suggest **CT** (with contrast) (↑).
3. In adults with suspected soft tissue infection, we suggest **US** to evaluate for superficial fluid collections (↑).
 - ↳ 3.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).
 - ↳ 3.2 If MRI is unavailable or contraindicated, we suggest **CT** (with contrast) (↑).

For imaging of foreign bodies, see Trauma guideline (T16. Superficial soft tissue injury foreign body)

M04. BONE TUMOUR – PRIMARY^{9,10,15,54}

1. In adults with suspected primary bone tumour, we recommend **XR** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).
 - ↳ 1.2 If MRI is unavailable or contraindicated, we suggest **CT** (with contrast) (↑).
 - ↳ 1.3 If XR, MRI or CT remain equivocal, we suggest **NM** (bone scan) (EP consensus).

M05. BONE TUMOUR – METASTASES^{9,54}

1. In adults with known primary cancer (non-myeloma), we recommend **NM** (bone scan) as the initial imaging modality to assess for skeletal metastases (↑↑).
2. In adults with suspected bone metastases, we recommend **XR** as the initial imaging modality for assessment of focal symptomatic sites, or for correlation with a NM, MRI or CT finding (↑↑).
3. In adults with metastases seen on XR requiring further local assessment or staging, we recommend **MRI** (↑↑).
 - ↳ 3.1 If MRI is unavailable or contraindicated, we suggest **CT** (with contrast) (↑).
4. In adults with suspected metastases, we recommend against **skeletal survey XR** (↓↓).
5. In adults with suspected bone metastases, **whole-body CT**, **whole-body MRI**, and **PET** are evolving techniques and may be used depending on regional practice preferences and resource availability (EP consensus).

M06. BONE TUMOUR – MYELOMA^{9,38,46,47,54}

1. In adults with suspected myeloma, we recommend **whole-body CT** (low dose) or **PET/CT** as the initial imaging modality for staging (↑↑).
 - ↳ 1.1 If whole-body CT or PET/CT is negative or unavailable, we recommend **whole-body MRI** as the next imaging modality (↑↑).
 - ↳ 1.2 If whole-body CT, PET/CT, and MRI are unavailable or contraindicated, we suggest **XR** (skeletal survey) (↑).
2. In adults with known myeloma, we recommend **XR** for assessment of focal symptomatic sites, or for correlation with an MRI or CT finding (↑↑).
3. In adults with suspected myeloma, we recommend against **NM** (bone scan) (↓↓).

M07. SOFT TISSUE MASS OR TUMOUR^{9,10,16,54}

1. In adults with superficial soft tissue mass, we recommend **US** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).
2. In adults with deep or large soft tissue mass (≥5 cm), we recommend **MRI** as the initial imaging modality (↑↑).
 - ↳ 2.1 If MRI is unavailable or contraindicated, we suggest **CT** (with contrast) (↑).
3. In adults with soft tissue masses, we recommend **XR** for evaluation of calcification, or if bone/joint involvement is suspected, after US (↑↑).

(continued)

Table 2. (continued)

Clinical/Diagnostic Scenario and Recommendations.

M08. SOFT TISSUE PAIN (NON-PERIARTICULAR)

1. In adults with non-joint soft tissue pain, we recommend **US** as the initial imaging modality (EP consensus).
 - ↳ 1.1 If further investigation is required, we recommend **MRI** as the next imaging modality (EP consensus).
 - ↳ 1.2 If MRI is unavailable or contraindicated, we suggest **CT** (with contrast) (EP consensus).
2. In adults with non-joint soft tissue pain, we suggest **XR** for evaluation of regional bone pathology (EP consensus).

CT, computed tomography; **MRI**, magnetic resonance imaging; **NM**, nuclear medicine; **PET**, positron emission tomography; **US**, ultrasound; **XR**, radiograph.
Strength of Recommendation: ↑↑: strong for; ↑: conditional for; ↓: conditional against; ↓↓: strong against; **EPc**: Expert Panel consensus.

^aFor bone scan, the radioisotope and protocol employed may vary based on clinical presentation, regional practice preferences and resource availability.

^bIf necrotizing fasciitis is suspected, surgical consultation should not be delayed by imaging. Imaging may be ordered concurrently with surgical consultation, or even bypassed at the discretion of the surgeon.

Table 3. Arthropathy, Bone Pain, Metabolic Bone Disease, Stress Fracture, and Chest Wall Pain Recommendations.

Clinical/Diagnostic Scenario and Recommendations.

M09. OSTEOARTHRITIS/CRYSTALLINE ARTHROPATHY^{12,17,35,37}

1. In adults with suspected osteoarthritis or crystalline arthropathy, we recommend **XR** as the initial imaging modality (↑↑).
2. In adults with suspected gout, we suggest **US** as a complement to XR to identify tophi (↑).
3. In adults with suspected gout, **CT** (dual-energy) may be used depending on regional practice preferences and resource availability (EP consensus).

M10. INFLAMMATORY ARTHROPATHY (RHEUMATOID/PERIPHERAL SPONDYLOARTHROPATHY)^{9,17,36,48,49,54}

1. In adults with suspected inflammatory arthropathy, we recommend **XR** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required for evaluation of findings such as effusion, synovitis, erosions and enthesitis, we suggest **US** as the next imaging modality (↑).
 - ↳ 1.2 In adults with multifocal joint pain, we suggest **NM** (bone scan) as an alternative to US to determine the distribution of synovitis (↑).
 - ↳ 1.3 If further investigation is required for evaluation of findings such as acute synovitis, cartilage damage, erosions, and bone marrow edema OR as an alternative to US, we suggest **MRI** (↑).

M11. SPONDYLOARTHROPATHY (AXIAL)^{9,18,31,50-52,54,56}

1. In adults with suspected axial spondyloarthropathy, we recommend **XR of the sacroiliac joints ± spine** as the initial imaging investigation (↑↑).
 - ↳ 1.1 If further investigation is required, we recommend **MRI of the sacroiliac joints ± spine** as the next imaging investigation (↑↑).
 - ↳ 1.2 If MRI is unavailable or contraindicated, we suggest **CT of the sacroiliac joints ± spine** (↑).
2. In adults with suspected axial spondyloarthropathy, we recommend against **NM** (bone scan) (↓↓).

M12. BONE PAIN (NON-JOINT)^{9,54}

1. In adults with non-traumatic, non-joint bone pain, we recommend **XR** of the symptomatic area(s) as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).
 - ↳ 1.2 If MRI is unavailable or contraindicated, we suggest **CT** (EP consensus).
 - ↳ 1.3 If CT is unavailable, we recommend **NM** (bone scan) (↑↑).

If concern for osteomyelitis, see M01. Osteomyelitis, including diabetic foot; for primary bone tumour, see M04. Bone tumour – Primary; for osseous metastasis, see M05. Bone tumour – Metastases; for myeloma, see M06. Bone tumour – Myeloma; for metabolic bone disease, see M13. Metabolic bone disease, including osteoporosis and osteomalacia; for stress fracture, see M14. Stress fracture (insufficiency and fatigue); for avascular necrosis/bone infarction, see M24. Avascular necrosis/bone infarction.

M13. METABOLIC BONE DISEASE, INCLUDING OSTEOPOROSIS AND OSTEOMALACIA^{9,19,53,54,57,58}

1. In adults with suspected osteoporosis, we recommend **dual-energy X-ray absorptiometry (DEXA)** for the measurement of bone mineral density (↑↑).
2. In adults with suspected metabolic bone disease with pain or focal area of concern, we recommend **XR** as the initial imaging modality (↑↑).
 - ↳ 2.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).
 - ↳ 2.2 If MRI is not available or is contraindicated, we suggest **CT** to evaluate focal pain (↑).
3. In adults with suspected metabolic bone disease with multi-focal areas of pain or concern, we suggest **NM** (bone scan) as the initial imaging modality (↑).

If concern for stress fracture, see M14. Stress fracture.

(continued)

Table 3. (continued)

Clinical/Diagnostic Scenario and Recommendations.

M14. STRESS FRACTURE (INSUFFICIENCY AND FATIGUE)²⁰

1. In adults with suspected stress (fatigue or insufficiency) fracture, we recommend **XR** of the area of interest as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required for evaluation of suspected stress fracture, we recommend **MRI** for the pelvis and hip (↑↑) and suggest **MRI** for any other sites (EP consensus) as the next imaging modality.
 - ↳ 1.2 If MRI is unavailable or is contraindicated or would result in a clinically significant delay in diagnosis, we suggest **CT** (↑).
 - ↳ 1.3 If CT is unavailable, we suggest **NM** (bone scan) (↑).

M15. CHEST WALL PAIN²¹

1. In adults with non-traumatic chest wall pain, we recommend **XR of the chest ± ribs** as the initial imaging investigation (↑↑).
 - ↳ 1.1 If further investigation is required for evaluation of focal chest wall or joint area of concern, we suggest **US** as the next imaging modality (↑).
 - ↳ 1.2 If further investigation is required, we recommend **MRI** (↑↑).
 - ↳ 1.3 If further investigation is required for evaluation of diffuse chest wall or intra-thoracic pathology, we recommend **CT** as the next imaging modality (↑↑).

CT, computed tomography; **MRI**, magnetic resonance imaging; **NM**, nuclear medicine; **US**, ultrasound; **XR**, radiograph.

Strength of Recommendation: ↑↑: strong for; ↑: conditional for; ↓: conditional against; ↓↓: strong against; **EPc**: Expert Panel consensus.

Table 4. Shoulder, Elbow, Hand/Wrist, MSK Pelvis or Hip, Knee, Ankle, Foot, and Orthopedic Hardware/Arthroplasty Pain, Avascular Necrosis/Bone Infarction, and Complex Regional Pain Syndrome Recommendations.

Clinical/Diagnostic Scenario and Recommendations.

M16. SHOULDER PAIN OR INSTABILITY^{9,11,22,37,54}

1. In adults with shoulder pain or instability, we recommend **XR** as the initial imaging modality (↑↑).^a
 - ↳ 1.1 If further investigation is required for evaluation of soft tissue pathology, such as rotator cuff tear, tendinopathy, effusion, bursitis, soft tissue calcification, or extra-articular impingement, we recommend **US** as the next imaging modality (↑↑).
 - ↳ 1.2 If further investigation is required OR as an alternative to US, we recommend **MRI** (↑↑).^b
 - ↳ 1.3 In adults with suspected labral tear, ligamentous and cartilage injuries, or instability, we recommend **MR arthrography** (↑↑) or **high-field MRI** (ie, 3T) (EP consensus), with selected MRI technique based on regional preference/availability/expertise.
 - ↳ 1.4 If MRI is unavailable or contraindicated, we suggest **CT arthrography** to evaluate for findings such as rotator cuff and/or labral tear (↑).
2. In adults with shoulder pain or instability, after XR, we suggest **CT** for evaluation of clinically relevant bone anatomy, in the context of pre-operative planning (↑).

M17. ELBOW PAIN³⁷

1. In adults with elbow joint pain of suspected articular origin, we recommend **XR** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).^b
2. In adults with elbow pain with suspected tendon pathology, nerve compression, effusion, synovitis, or bursitis, we recommend **XR** or **US** as the initial imaging modality (↑↑).
 - ↳ 2.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).
3. In adults with elbow pain, after XR, we suggest **CT** for evaluation of clinically relevant bone anatomy, in the context of pre-operative planning (↑).

M18. HAND AND WRIST PAIN^{23,37}

1. In adults with hand and/or wrist joint pain, we suggest **XR** as the initial imaging modality (↑).^c
 - ↳ 1.1 If further investigation is required, we suggest **MRI** (↑).^b
 - ↳ 1.2 If MRI is unavailable or contraindicated, we suggest **CT arthrography** for the evaluation of the triangulofibrocarrilaginous complex (TFCC), intrinsic ligaments of the wrist or capsule (↑).
2. In adults with hand and/or wrist pain suspected to be soft tissue related, such as ganglion cyst, synovitis, tenosynovitis, we suggest **US** as the initial imaging modality (↑).
 - ↳ 2.1 As an alternative to US, we suggest **MRI** (↑).
3. In adults with hand and/or wrist pain, after XR, we suggest **CT** for evaluation of bone anatomy, chronic scaphoid fracture OR in the context of pre-operative planning (↑).

For suspected inflammatory arthritis of the wrist, see M09. Inflammatory Arthropathy (Rheumatoid/Peripheral Spondyloarthropathy).

(continued)

Table 4. (continued)

Clinical/Diagnostic Scenario and Recommendations.

M19. MSK PELVIS OR HIP PAIN^{9,24,37,41-44,54}**Hip pain**

1. In adults with hip pain, we recommend **XR** as the initial imaging modality (↑↑).^d
2. For evaluation of internal derangement of the hip such as labral tear, osteochondral injury, or intraarticular body and if further investigation is required, we recommend **MR arthrography** (↑↑) or **high-field MRI** (ie, 3T) (EP consensus).^{b,e}
 - ↳ 2.1 If MRI is unavailable or is contraindicated, we suggest **CT arthrography** for evaluation for internal derangement of the hip (↑).
3. For evaluation of deep soft tissue pathology, after XR, we recommend **MRI** as the next imaging modality (↑↑).
4. For evaluation of superficial soft tissue pathology, after XR, we recommend **US** or **MRI** (↑↑).
5. In adults with hip pain, we suggest **CT** for evaluation of clinically relevant bone anatomy, typically in the context of pre-operative planning (EP consensus).

Musculoskeletal Pelvic pain (including osteitis pubis or athletic pubalgia)

6. In adults with musculoskeletal pelvic pain, we suggest **XR** as the initial imaging modality (EP consensus).
 - ↳ 6.1 If further investigation is required, we suggest **MRI** as the next imaging modality (EP consensus).
 - ↳ 6.2 If MRI is unavailable or contraindicated, we suggest **US** if pathology is favoured to be soft tissue related, as the next imaging modality (EP consensus).
 - ↳ 6.3 If MRI is unavailable or contraindicated, we suggest **CT** or **NM (bone scan)** if pathology is favoured to be osseous, as the next imaging modality (EP consensus).

For sacroiliac joint pathology, see M10. Inflammatory Arthropathy; suspected fracture, see M14. Stress fracture; avascular necrosis of the hip, see M24. Avascular necrosis.

M20. KNEE PAIN^{9,25,37,54}

1. In adults with knee joint pain, we recommend **XR** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required, we recommend **MRI** as the next imaging modality (↑↑).^b
 - ↳ 1.2 If MRI is unavailable or contraindicated, we suggest CT arthrography to evaluate for findings such as meniscal tear or chondral defects (↑).
2. In adults with knee pain suspected to be soft tissue related, such as extensor mechanism pathology, bursitis, joint effusion, and popliteal cyst/mass, we recommend **US** as the initial imaging modality (↑↑).
 - ↳ 2.1 As an alternative to US, we recommend **MRI** as the next imaging modality (↑↑).
3. In adults with chronic knee joint pain, after XR, we suggest **CT** for evaluation of clinically relevant bone anatomy in scenarios such as patellofemoral maltracking, osteochondral defect, or intraarticular bodies (↑) OR in the context of pre-operative planning (EP consensus).

M21. ANKLE PAIN^{26,37}

1. In adults with ankle pain, we recommend **XR** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required for evaluation of effusion or tendon abnormality, we recommend **US** as the next imaging modality (↑↑).
 - ↳ 1.2 If further investigation is required to evaluate for findings such as osteochondral lesion or unstable ligament tears, or as an alternative to US for tendon pathology, we recommend **MRI** as the next imaging modality (↑↑).^b
2. In adults with ankle pain, after XR, we suggest **CT** for evaluation of clinically significant bone anatomy in scenarios such as osteochondral defect, intraarticular bodies, tarsal coalition (↑) OR in the context of pre-operative planning (EP consensus).

M22. FOOT PAIN^{9,27,37,54}

1. In adults with foot pain, we suggest **XR** as the initial imaging modality (↑).
2. In adults with foot pain suspected to be soft tissue related, such as plantar fasciitis, tendon pathology, bursitis, Morton's neuroma, we suggest **US** as the next imaging modality (↑).
 - ↳ 2.1 If further investigation is required for evaluation for findings such as stress fracture, tarsal coalition, plantar fasciitis, tarsal tunnel syndrome, tendon pathology, or Morton's neuroma, we suggest **MRI** (↑).^b
3. In adults with foot pain, after XR, we suggest **CT** for evaluation of pathologies such as stress fracture, osteochondral defect (↑↑) or for evaluation of clinically relevant bone anatomy, typically in the context of pre-operative planning (EP consensus).
4. In adults with foot pain suspected to be a stress fracture, if MRI and CT are unavailable or contraindicated, we suggest **NM (bone scan)** (↑).

(continued)

Table 4. (continued)

Clinical/Diagnostic Scenario and Recommendations.

M23. ORTHOPEDIC HARDWARE/ARTHROPLASTY PAIN/SYMPTOMS^{9,13,28,29,33,34,40,54}

1. In adults with orthopedic hardware/arthroplasty pain or symptoms, we recommend **XR** as the initial imaging modality, to evaluate for findings such as fracture, dislocation, periprosthetic osteolysis, or hardware fracture/loosening (↑↑).
 - ↳ 1.1 If further investigation is required for evaluation of periprosthetic osteolysis or fracture, we recommend **CT** as the next imaging modality (↑↑). Metal artifact reduction parameters should be implemented.
 - ↳ 1.2 In adults with orthopedic hardware/arthroplasty pain or symptoms suspicious for infection, loosening, or fracture, we recommend **NM** (bone scan) when CT is negative, indeterminate, or unavailable (↑↑).^f
2. In adults with orthopedic hardware/arthroplasty pain or symptoms suspected to be related to soft tissue pathology, after XR, we recommend **MRI** as the next imaging modality (↑↑). Metal artifact reduction sequences should be implemented.
 - ↳ 2.1 If MRI is not available or contraindicated, we suggest **CT** (with contrast) (↑).
3. In adults with orthopedic hardware/arthroplasty pain or symptoms, we recommend **US** to evaluate for superficial fluid collections (↑↑).
4. In adults with orthopedic hardware/arthroplasty pain or symptoms concerning for septic arthritis, after XR, we suggest **US** or **fluoroscopy** to facilitate arthrocentesis (EP consensus).

M24. AVASCULAR NECROSIS/BONE INFARCTION^{9,30,39,54}

1. In adults with suspected avascular necrosis/bone infarction, we recommend **XR** as the initial imaging (↑↑).
 - ↳ 1.1 If further investigation is required for evaluation of avascular necrosis, we recommend **MRI** as the next imaging modality (↑↑).
 - ↳ 1.2 If MRI is unavailable or is contraindicated, we suggest **NM** (bone scan) (↑).
 - ↳ 1.3 If MRI and NM (bone scan) are unavailable or contraindicated, we suggest **CT** (↑).

M25. COMPLEX REGIONAL PAIN SYNDROME^{22,27}

1. In adults with suspected complex regional pain syndrome, we suggest **XR** as the initial imaging modality (↑↑).
 - ↳ 1.1 If further investigation is required, we suggest **NM** (bone scan) as the next imaging modality (EP consensus).
 - ↳ 1.2 If NM is unavailable or is contraindicated, we suggest **MRI** (EP consensus).

CT, computed tomography; **MRI**, magnetic resonance imaging; **NM**, nuclear medicine; **US**, ultrasound; **XR**, radiograph.

Strength of Recommendation: ↑↑: strong for; ↑: conditional for; ↓: conditional against; ↓↓: strong against; **EPc**: Expert Panel consensus

^aFor evaluation of instability, routine XR series may need to be supplemented with specialized radiographic projections, based on regional practice preferences.

^bFor assessment of degenerative joint pathology, if XR demonstrates greater than mild osteoarthritis, MRI may not be indicated as it often will not advance diagnosis or management. Specialist consultation should be considered, to determine if MRI is required.

^cRoutine XR series may need to be supplemented with specialized radiographic projections, based on clinical presentation and regional practice preferences.

^dRoutine XR series may need to be supplemented with specialized radiographic projections, for conditions such as femoroacetabular impingement (FAI), hip dysplasia, or post-traumatic deformity, based on clinical concern and regional practice preferences.

^eIf XR demonstrates features associated with femoroacetabular impingement (FAI) or hip dysplasia, then consultation to orthopaedic surgery or sports medicine specialist is suggested as MRI may not be the most appropriate, next investigative modality.

^fFor bone scan, the radioisotope and protocol employed may vary based on clinical presentation, regional practice preferences and resource availability.

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Supplemental Material

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