

ACR Appropriateness Criteria[®]

Thoracic Back Pain

Expert Panel on Neurological Imaging: Vinil N. Shah, MD^a, Matthew S. Parsons, MD^b, Daniel J. Boulter, MD^c, Judah Burns, MD^d, Brian Callaghan, MD, MS^e, Rami Eldaya, MD^f, Michael Hanak, MD^g, Alvand Hassankhani, MD^h, Troy A. Hutchins, MDⁱ, Christopher D. Jackson, MD^j, Majid A. Khan, MD^k, Jeff Mullin, MD, MBA^l, A. Orlando Ortiz, MD, MBA^m, Charles Reitman, MDⁿ, Christopher Sampson, MD^o, Claire K. Sandstrom, MD^p, Vincent M. Timpone, MD^q, Andrew T. Trout, MD^r, Bruno Policeni, MD, MBA^s

^aUniversity of California San Francisco, San Francisco, California.

^bPanel Chair, Mallinckrodt Institute of Radiology, Saint Louis, Missouri.

^cThe Ohio State University Wexner Medical Center, Columbus, Ohio.

^dMontefiore Medical Center, Bronx, New York.

^eUniversity of Michigan, Ann Arbor, Michigan; American Academy of Neurology.

^fWashington University School of Medicine, Saint Louis, Missouri.

^gRush University Medical Center, Chicago, Illinois; American Academy of Family Physicians.

^hHospital of the University of Pennsylvania, Philadelphia, Pennsylvania.

ⁱUniversity of Utah Health, Salt Lake City, Utah.

^jThe University of Tennessee Health Science Center, Memphis, Tennessee; Society of General Internal Medicine.

^kThomas Jefferson University Hospital, Philadelphia, Pennsylvania.

^lUniversity at Buffalo, Buffalo, New York; American Association of Neurological Surgeons/Congress of Neurological Surgeons.

^mJacobi Medical Center, Bronx, New York.

ⁿMedical University of South Carolina, Charleston, South Carolina; North American Spine Society.

^oUniversity of Missouri School of Medicine, Columbia, Missouri; American College of Emergency Physicians.

^pUniversity of Washington Medical Center, Seattle, Washington; Committee on Emergency Radiology-GSER.

^qMayo Clinic, Phoenix, Arizona.

^rCincinnati Children's Hospital Medical Center, Cincinnati, Ohio; Commission on Nuclear Medicine and Molecular Imaging.

^sSpecialty Chair, University of Iowa Hospitals and Clinics, Iowa City, Iowa. Corresponding author: Vinil Shah, MD. 505 Parnassus Avenue, L-371, San Francisco, CA 94143; e-mail: vinil.shah@ucsf.edu.

The American College of Radiology seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply individual or society endorsement of the final document. Reprint requests to: publications@acr.org.

Brian Callaghan, MD, MS, reports grants or contracts from National Institute of Diabetes and Digestive and Kidney Diseases, Juvenile Diabetes

Research Foundation, American Academy of Neurology; consulting fees from Dynamed; American Academy of Neurology editorial board; payment for expert testimony from Medical legal work including the vaccine injury compensation program. Christopher D. Jackson, MD, reports leadership roles as American College of Physicians Population Health and Medical Sciences Subcommittee and United States Medical Licensing Examination Step 3 Test Material Development Committee, Southern Medical Association President, Society of General Internal Medicine Council. Claire K. Sandstrom, MD, reports payments or honoraria from Honorarium for Grand Rounds lecture at Mass General Hospital/Brigham & Women's, Honorarium for Grand Rounds lecture at Beth Israel Deaconess MC, Honorarium for lecture for Everlearning; leadership roles as Chair, Fellow Education Committee, American Society of Emergency Radiology. Michael Hanak, MD, reports payment for expert testimony relating to an existing patient in the role of a treating clinician; support for meetings from American Academy of Family Physicians reimburses business expenses related to representing the organization in forums like the AMA House of Delegates and CPT Advisory Council (alternate advisor); leadership roles as Chairperson of the American Academy of Family Physicians delegation to the AMA; sits on American Academy of Family Physicians Commission on Quality and Practice; serves as associate CMO at Rush University Medical Center. Majid A. Khan, MD, reports consulting fees from Stryker Medical, Hy prevention, Medwaves Aveure; payment for expert testimony as an expert witness in medicolegal cases. Matthew S. Parsons, MD, reports leadership roles as Neuroradiology Fellowship Director. Charles Reitman, MD, reports consulting fees from Medical Metrics (<\$1,000). Paid to me; payment for expert testimony to institution; leadership roles as North American Spine Society. Christopher Sampson, MD, reports leadership roles as Vice Chair-Research, Department of Emergency Medicine University of Missouri School of Medicine. The other authors state that they have no conflict of interest related to the material discussed in this article. Jeff Mullin, MD, MBA, is a partner; and all other authors are non-partner/non-partnership track/employees.

The ACR Appropriateness Criteria documents are updated regularly. Please go to the ACR website at www.acr.org/ac to confirm that you are accessing the most current content.

Disclaimer: The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

Abstract

Thoracic back pain is a common site for inflammatory, neoplastic, metabolic, infectious, and degenerative conditions, and may be associated with significant disability and morbidity. Uncomplicated acute thoracic back pain and/or radiculopathy does not typically warrant imaging. Imaging may be considered in those patients who have persistent pain despite 6 weeks of conservative treatment. Early imaging may also be warranted in patients presenting with “red flag” history or symptoms, including those with a known or suspected history of cancer, infection, immunosuppression, or trauma; in myelopathic patients; or in those with a history of prior thoracic spine fusion.

The American College of Radiology Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed annually by a multidisciplinary expert panel. The guideline development and revision process support the systematic analysis of the medical literature from peer reviewed journals. Established methodology principles such as Grading of Recommendations Assessment, Development, and Evaluation or GRADE are adapted to evaluate the evidence. The RAND/UCLA Appropriateness Method User Manual provides the methodology to determine the appropriateness of imaging and treatment procedures for specific clinical scenarios. In those instances where peer reviewed literature is lacking or equivocal, experts may be the primary evidentiary source available to formulate a recommendation.

Key Words: Appropriateness Criteria, appropriate use criteria, AUC, cancer, imaging, myelopathy, radiculopathy, spinal fusion, thoracic back pain

J Am Coll Radiol 2024;21:S504-S517. Copyright © 2024 American College of Radiology

ACR Appropriateness Criteria® Thoracic Back Pain. [Variants 1 to 7](#) and [Tables 1 and 2](#).

Variant 1. Adult. Acute thoracic back pain without myelopathy or radiculopathy. No red flags. No prior management. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography thoracic spine	Usually Not Appropriate	⚠⚠⚠
MRI thoracic spine with IV contrast	Usually Not Appropriate	○
MRI thoracic spine without and with IV contrast	Usually Not Appropriate	○
MRI thoracic spine without IV contrast	Usually Not Appropriate	○
Bone scan whole body	Usually Not Appropriate	⚠⚠⚠
Bone scan with SPECT or SPECT/CT thoracic spine	Usually Not Appropriate	⚠⚠⚠
CT thoracic spine with IV contrast	Usually Not Appropriate	⚠⚠⚠
CT thoracic spine without IV contrast	Usually Not Appropriate	⚠⚠⚠
CT myelography thoracic spine	Usually Not Appropriate	⚠⚠⚠⚠
CT thoracic spine without and with IV contrast	Usually Not Appropriate	⚠⚠⚠⚠
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⚠⚠⚠⚠

Variant 2. Adult. Subacute or chronic thoracic back pain without myelopathy or radiculopathy. No red flags. Failed conservative management. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography thoracic spine	May Be Appropriate (Disagreement)	⚠️⚠️⚠️
MRI thoracic spine with IV contrast	Usually Not Appropriate	0
MRI thoracic spine without and with IV contrast	Usually Not Appropriate	0
MRI thoracic spine without IV contrast	Usually Not Appropriate	0
Bone scan whole body	Usually Not Appropriate	⚠️⚠️⚠️
Bone scan with SPECT or SPECT/CT thoracic spine	Usually Not Appropriate	⚠️⚠️⚠️
CT thoracic spine with IV contrast	Usually Not Appropriate	⚠️⚠️⚠️
CT thoracic spine without IV contrast	Usually Not Appropriate	⚠️⚠️⚠️
CT myelography thoracic spine	Usually Not Appropriate	⚠️⚠️⚠️⚠️
CT thoracic spine without and with IV contrast	Usually Not Appropriate	⚠️⚠️⚠️⚠️
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⚠️⚠️⚠️⚠️

Variant 3. Adult. Thoracic back pain with myelopathy or radiculopathy. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI thoracic spine without IV contrast	Usually Appropriate	0
Radiography thoracic spine	May Be Appropriate	⚠️⚠️⚠️
MRI thoracic spine without and with IV contrast	May Be Appropriate (Disagreement)	0
CT thoracic spine without IV contrast	May Be Appropriate (Disagreement)	⚠️⚠️⚠️
CT myelography thoracic spine	May Be Appropriate	⚠️⚠️⚠️⚠️
MRI thoracic spine with IV contrast	Usually Not Appropriate	0
Bone scan whole body	Usually Not Appropriate	⚠️⚠️⚠️
Bone scan with SPECT or SPECT/CT thoracic spine	Usually Not Appropriate	⚠️⚠️⚠️
CT thoracic spine with IV contrast	Usually Not Appropriate	⚠️⚠️⚠️
CT thoracic spine without and with IV contrast	Usually Not Appropriate	⚠️⚠️⚠️⚠️
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⚠️⚠️⚠️⚠️

Variant 4. Adult. Thoracic back pain without or with myelopathy or radiculopathy. One or more of the following: low-velocity trauma, osteoporosis, elderly individual, or chronic steroid use. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography thoracic spine	Usually Appropriate	⦿⦿⦿
MRI thoracic spine without IV contrast	Usually Appropriate	○
CT thoracic spine without IV contrast	Usually Appropriate	⦿⦿⦿
MRI thoracic spine without and with IV contrast	May Be Appropriate	○
Bone scan whole body	May Be Appropriate	⦿⦿⦿
Bone scan with SPECT or SPECT/CT thoracic spine	May Be Appropriate	⦿⦿⦿
MRI thoracic spine with IV contrast	Usually Not Appropriate	○
CT thoracic spine with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT myelography thoracic spine	Usually Not Appropriate	⦿⦿⦿⦿
CT thoracic spine without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⦿⦿⦿⦿

Variant 5. Adult. Thoracic back pain without or with myelopathy or radiculopathy. One or more of the following: suspicion of cancer, infection, or immunosuppression. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI thoracic spine without and with IV contrast	Usually Appropriate	○
MRI thoracic spine without IV contrast	Usually Appropriate	○
Radiography thoracic spine	May Be Appropriate	⦿⦿⦿
CT thoracic spine without IV contrast	May Be Appropriate	⦿⦿⦿
CT myelography thoracic spine	May Be Appropriate	⦿⦿⦿⦿
MRI thoracic spine with IV contrast	Usually Not Appropriate	○
Bone scan whole body	Usually Not Appropriate	⦿⦿⦿
Bone scan with SPECT or SPECT/CT thoracic spine	Usually Not Appropriate	⦿⦿⦿
CT thoracic spine with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT thoracic spine without and with IV contrast	Usually Not Appropriate	⦿⦿⦿⦿
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⦿⦿⦿⦿

Variant 6. Adult. Thoracic back pain without or with myelopathy or radiculopathy. Radiograph shows bone destruction or fracture or spinal deformity. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
MRI thoracic spine without and with IV contrast	Usually Appropriate	○
MRI thoracic spine without IV contrast	Usually Appropriate	○
CT thoracic spine without IV contrast	Usually Appropriate	⊕⊕⊕
CT myelography thoracic spine	May Be Appropriate	⊕⊕⊕⊕
MRI thoracic spine with IV contrast	Usually Not Appropriate	○
Bone scan whole body	Usually Not Appropriate	⊕⊕⊕
Bone scan with SPECT or SPECT/CT thoracic spine	Usually Not Appropriate	⊕⊕⊕
CT thoracic spine with IV contrast	Usually Not Appropriate	⊕⊕⊕
CT thoracic spine without and with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⊕⊕⊕⊕

Variant 7. Adult. Thoracic back pain without or with myelopathy or radiculopathy. Post thoracic spine surgery. Follow-up imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography thoracic spine	Usually Appropriate	⊕⊕⊕
MRI thoracic spine without and with IV contrast	Usually Appropriate	○
MRI thoracic spine without IV contrast	Usually Appropriate	○
CT thoracic spine without IV contrast	Usually Appropriate	⊕⊕⊕
CT myelography thoracic spine	May Be Appropriate	⊕⊕⊕⊕
MRI thoracic spine with IV contrast	Usually Not Appropriate	○
Bone scan whole body	Usually Not Appropriate	⊕⊕⊕
Bone scan with SPECT or SPECT/CT thoracic spine	Usually Not Appropriate	⊕⊕⊕
CT thoracic spine with IV contrast	Usually Not Appropriate	⊕⊕⊕
CT thoracic spine without and with IV contrast	Usually Not Appropriate	⊕⊕⊕⊕
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	⊕⊕⊕⊕

Table 1. Appropriateness category names and definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Table 2. Relative radiation level designations

RRL	Adult Effective Dose Estimate Range (mSv)	Pediatric Effective Dose Estimate Range (mSv)
○	0	0
⊗	<0.1	<0.03
⊗⊗	0.1-1	0.03-0.3
⊗⊗⊗	1-10	0.3-3
⊗⊗⊗⊗	10-30	3-10
⊗⊗⊗⊗⊗	30-100	10-30

Note: Relative radiation level (RRL) assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "varies."

SUMMARY OF LITERATURE REVIEW

Introduction/Background

In the United States, spinal pain is one of the leading causes of disability, health care costs, and emergency department visits [1,2]. The lumbar and cervical spine regions have been extensively studied and have well-established associations with pain and disability. Comparatively, thoracic back pain (TBP) has received less attention in terms of genetic and epidemiological research [3]. However, the thoracic spine is a common site for inflammatory, neoplastic, metabolic, infectious, and degenerative conditions [3]. Therefore, TBP may be equally disabling and associated with significant morbidity.

For the purposes of this document, TBP is defined as pain experienced in the region of the thoracic spine and emanating from pain generators in the thoracic spine (T1-T12) or thoracic paraspinal soft tissues. Although there is great variability in the definition of acute and subacute back pain, this document will use definitions of 0 to 4 weeks for acute TBP, 4 to 12 weeks for subacute TBP, and >12 weeks for chronic TBP [4].

Uncomplicated acute TBP and/or radiculopathy may be a benign, self-limited condition that does not warrant any

imaging studies [5-8]. Imaging may be considered in those patients who have had up to 6 weeks of medical management and physical therapy that resulted in little or no improvement in their back pain. Imaging may also be considered for those patients presenting with red flags, raising suspicion for a serious underlying condition, such as symptomatic spinal canal stenosis, cord deformity or compression, malignancy, fracture, or infection [9,10].

For those patients with significant trauma, myelopathy, or prior thoracic spine fusion, early imaging may also be warranted [11-14]. Because the thoracic spine is a common site for osteoporotic compression fractures [15-17], early imaging should also be considered in patients with known osteoporosis or risk factors such as >65 years of age or chronic steroid use [18].

For those patients without neurologic compromise and who present with minor risk factors for cancer, inflammatory back disease (eg, ankylosing spondylitis), vertebral compression fracture, or symptomatic spinal stenosis, imaging may be considered after a trial of therapy.

Other nonspine causes of TBP can overlap in clinical presentation, including inflammatory arthritis and other

systemic conditions, such as intrathoracic, renal, vascular, or gastrointestinal etiologies. If an inflammatory etiology is suspected as the cause of TBP, such as ankylosing spondylitis, psoriatic spondylitis, reactive arthritis, or inflammatory bowel disease–related spine disorders, see the ACR Appropriateness Criteria® topic on “Inflammatory Back Pain: Known or Suspected Axial Spondyloarthritis” [19].

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient’s care)
OR
- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient’s care).

DISCUSSION OF PROCEDURES BY VARIANT

Variant 1: Adult. Acute thoracic back pain without myelopathy or radiculopathy. No red flags. No prior management. Initial imaging

There is a lack of evidence supporting or refuting imaging early or before conservative treatment for TBP [3,20]. However, extrapolating from the low back pain (LBP) evidence, imaging is typically not warranted in this setting. Acute (<4 weeks’ duration), uncomplicated (no red flags) LBP with or without radiculopathy, is considered a self-limiting condition that is responsive to medical management and physical therapy in most patients [5–8]. Numerous studies have shown routine imaging provides no clinical benefit in this LBP group [6].

Thoracic disc disease is less common than in the cervical or lumbar spine [21]. This may be due to the fact that the thoracic spine is the only portion of the spine with additional structures (ie, ribs) to help in weight-bearing. There is also relatively limited mobility in the thoracic spine as the costovertebral joint limits flexion, the rib cage limits rotation and lateral bending, and the discs are relatively small in size compared to the cervical or lumbar spine. Symptomatic thoracic disc disease occurs most frequently below the level of T7. Thoracic disc abnormalities such as herniations, bulges, annular fissures, and cord contour deformity are common in asymptomatic patients [22]. Thoracic disc imaging abnormalities can therefore be seen in a substantial number of people without mid back pain.

With regards to thoracic facet joints, as in the lumbar spine, morphologic imaging changes of osteoarthritis do not correlate with pain [23].

Bone Scan Whole Body. There is no relevant literature to support the use of bone scans whole body in the initial evaluation of acute uncomplicated TBP.

Bone Scan With SPECT or SPECT/CT Thoracic Spine. There is no relevant literature to support the use of bone scans with single-photon emission CT (SPECT) or SPECT/CT thoracic spine in the initial evaluation of acute uncomplicated TBP.

CT Myelography Thoracic Spine. There is no relevant literature to support the use of CT myelography thoracic spine in the initial evaluation of acute uncomplicated TBP. No radiologic distinction has been noted between asymptomatic and symptomatic discs on postmyelographic CT [24].

CT Thoracic Spine With IV Contrast. There is no relevant literature to support the use of CT thoracic spine with intravenous (IV) contrast in the initial evaluation of acute uncomplicated TBP.

CT Thoracic Spine Without and With IV Contrast. There is no relevant literature to support the use of CT thoracic spine without and with IV contrast in the initial evaluation of acute uncomplicated TBP.

CT Thoracic Spine Without IV Contrast. There is no relevant literature to support the use of CT thoracic spine without IV contrast in the initial evaluation of acute uncomplicated TBP.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/CT skull base to mid-thigh in the initial evaluation of acute uncomplicated TBP.

MRI Thoracic Spine With IV Contrast. There is no relevant literature to support the use of MRI thoracic spine with IV contrast in the initial evaluation of acute uncomplicated TBP.

MRI Thoracic Spine Without and With IV Contrast. There is no relevant literature to support the use of MRI thoracic spine without and with IV contrast in the initial evaluation of acute uncomplicated TBP.

MRI Thoracic Spine Without IV Contrast. There is no relevant literature to support the use of MRI thoracic spine without IV contrast in the initial evaluation of acute uncomplicated TBP.

Radiography Thoracic Spine. There is no relevant literature to support the use of radiography in the initial evaluation of acute uncomplicated TBP.

Variant 2: Adult. Subacute or chronic thoracic back pain without myelopathy or radiculopathy. No red flags. Failed conservative management. Initial imaging

As with acute TBP, few studies support or refute imaging for patients with subacute or chronic midback pain without neurologic symptoms. However, as with LBP, imaging is typically not considered useful in this setting [6,7]. For patients with subacute (4-12 weeks' duration) or chronic (>12 weeks' duration) TBP without red flags or prior management, conservative therapy should still be considered first-line [25].

Bone Scan Whole Body. There is no relevant literature to support the use of bone scans whole body in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

Bone Scan With SPECT or SPECT/CT Thoracic Spine. There is no relevant literature to support the use of bone scans with SPECT or SPECT/CT thoracic spine in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

CT Myelography Thoracic Spine. There is no relevant literature to support the use of CT myelography thoracic spine in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

CT Thoracic Spine With IV Contrast. There is no relevant literature to support the use of CT thoracic spine with IV contrast in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

CT Thoracic Spine Without and With IV Contrast. There is no relevant literature to support the use of CT thoracic spine without and with IV contrast in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

CT Thoracic Spine Without IV Contrast. There is no relevant literature to support the use of CT thoracic spine without IV contrast in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT skull base to mid-thigh in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

MRI Thoracic Spine With IV Contrast. There is no relevant literature to support the use of MRI thoracic spine with IV contrast in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

MRI Thoracic Spine Without and With IV Contrast. There is no relevant literature to support the use of MRI thoracic spine without and with IV contrast in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

MRI Thoracic Spine Without IV Contrast. There is no relevant literature to support the use of MRI thoracic spine without IV contrast in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

Radiography Thoracic Spine. There is no relevant literature to support the use of radiography in the initial evaluation of subacute or chronic TBP without red flags or neurologic deficits.

Variant 3: Adult. Thoracic back pain with myelopathy or radiculopathy. Initial imaging

The goal of imaging is to identify potential actionable pain generators that could be targeted for medical treatment, intervention, or surgery. MRI of the thoracic spine has become the initial imaging modality of choice in these patients [13,26,27].

Thoracic myelopathy is most commonly due to compressive etiologies, including structural causes resulting in spinal canal stenosis, cord compression/deformity, or other inflammatory, infectious, vascular, or neoplastic etiologies [28]. Spinal stenosis is a common cause of myelopathy, typically from disc herniations (including giant calcified disc herniations), usually below T7, facet arthropathy, or ligamentum flavum ossification [29].

Symptomatic thoracic disc herniations are more common in patients in their third to fifth decades of life and, in more than one-third of patients, are associated with a history of trauma. On imaging, these are often calcified (20%-65%) and sometimes intradural (5%-10%) [30]. Patients with symptomatic thoracic disc herniations may have thoracic midback pain (76%), motor/sensory deficit (61%), spasticity/hyperreflexia (58%), positive Babinski sign (55%), or bladder dysfunction (24%). Symptomatic thoracic disc herniations requiring surgery are rare, accounting for 1% to 2% of all discectomies [31]. Indication for surgery is usually severe, intractable pain, or progressive/severe myelopathy.

Thoracic radiculopathy is most commonly due to mechanical nerve root compression from degenerative, metabolic, infectious, or neoplastic causes.

Bone Scan Whole Body. There is no relevant literature to support the use of whole-body bone scans in the initial imaging of TBP and myelopathy or radiculopathy.

Bone Scan With SPECT or SPECT/CT Thoracic Spine. There is no relevant literature to support the use of bone scan with SPECT or SPECT/CT in the initial imaging of TBP and myelopathy or radiculopathy.

CT Myelography Thoracic Spine. CT myelography of the thoracic spine can be useful in assessing the patency of the spinal canal/theal sac. CT myelography may also be complementary to MRI for identifying and differentiating between certain causes of myelopathy, such as ventral cord herniation versus dorsal thoracic arachnoid web or cyst, and also for presurgical or preradiation treatment planning due to its high detail and exquisite resolution of the contents of the spinal canal [32]. CT myelography has the disadvantage of requiring lumbar puncture for intrathecal injection of myelographic contrast.

CT Thoracic Spine With IV Contrast. There is no relevant literature to support the use of CT thoracic spine with IV contrast in the initial imaging of TBP and myelopathy or radiculopathy.

CT Thoracic Spine Without and With IV Contrast. There is no relevant literature to support the use of CT thoracic spine without and with IV contrast in the initial imaging of TBP and myelopathy or radiculopathy.

CT Thoracic Spine Without IV Contrast. There is no relevant literature to support the use of CT thoracic spine without IV contrast in the initial imaging of TBP and myelopathy or radiculopathy. However, CT thoracic spine without IV contrast may be useful for preoperative planning. CT delineates osseous structures and anatomy with high resolution and can aid in trajectory planning for hardware fixation.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT skull base to mid-thigh in the initial imaging of TBP and myelopathy or radiculopathy.

MRI Thoracic Spine With IV Contrast. MRI thoracic spine with IV contrast is not typically performed independently as an initial study, because its interpretation is most informative when correlated with standard noncontrast sequences included in MRI thoracic spine with and without IV contrast.

MRI Thoracic Spine Without and With IV Contrast. MRI thoracic spine without and with IV contrast may be the preferred initial study of choice in patients with TBP and myelopathy/radiculopathy when underlying malignancy, infection, or inflammation is clinically suspected.

MRI Thoracic Spine Without IV Contrast. MRI thoracic spine without IV contrast may be useful as an initial study of choice in patients with TBP and myelopathy/

radiculopathy when structural/mechanical causes of compressive myelopathy or radiculopathy are clinically suspected. MRI thoracic spine without IV contrast is most useful in evaluating compressive myelopathy or radiculopathy because of its ability to accurately depict soft tissue pathology, assess vertebral marrow, and assess the spinal canal patency [20]. Heavily T2-weighted sequences such as constructive interference in steady state/fast imaging employing steady-state acquisition may be helpful to assess for structural etiologies such as dorsal thoracic arachnoid webs or for reducing metallic artifacts in patients with thoracic spinal hardware [33].

Radiography Thoracic Spine. There is no relevant literature to support the use of thoracic spine radiography in the initial evaluation of patients with TBP and myelopathy. Radiography alone is not usually sufficient for diagnosing the specific pain generator in these patients or for guiding surgical or interventional options without MRI and/or CT imaging. However, it can provide complementary information that can be helpful in treatment planning, including for presurgical planning and postoperative assessment [11].

Variant 4: Adult. Thoracic back pain without or with myelopathy or radiculopathy. One or more of the following: low-velocity trauma, osteoporosis, elderly individual, or chronic steroid use. Initial imaging

Elderly (>65 years of age) individuals, those with known osteoporosis, prior benign nontraumatic compression fracture, or chronic steroid use are at risk for additional compression fractures even with minimal to no trauma [34,35].

Patients with low-velocity trauma, and without risk factors for osteoporosis, may not need dedicated thoracic spine imaging if asymptomatic.

Bone Scan Whole Body. Whole-body bone scans may be helpful in the setting of compression fracture(s) to help identify fracture acuity and to appropriately select patients for intervention [36], particularly if MRI cannot be safely/easily obtained.

Bone Scan With SPECT or SPECT/CT Thoracic Spine. Bone scan with SPECT or SPECT/CT may be helpful in the setting of compression fracture(s) to help identify fracture acuity and to appropriately select patients for intervention [36].

CT Myelography Thoracic Spine. There is no relevant literature to support the use of CT myelography thoracic spine in the initial imaging assessment of this group.

CT Thoracic Spine With IV Contrast. There is no relevant literature to support the use of CT thoracic spine with IV contrast in the initial imaging assessment of this group.

CT Thoracic Spine Without and With IV Contrast. There is no relevant literature to support the use of CT thoracic spine without and with IV contrast in the initial imaging assessment of this group.

CT Thoracic Spine Without IV Contrast. CT thoracic spine without IV contrast may be useful as an initial study in the emergency room setting or for presurgical planning, particularly if radiographs are negative [36].

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT skull base to mid-thigh in the initial imaging assessment of this group.

MRI Thoracic Spine With IV Contrast. MRI thoracic spine with IV contrast is not typically performed independently as an initial study, because its interpretation is most informative when correlated with standard noncontrast sequences included in MRI thoracic spine with and without IV contrast.

MRI Thoracic Spine Without and With IV Contrast. MRI thoracic spine without and with IV contrast is not typically performed as an initial study in this group unless there is concern for underlying neoplasm, infection, or inflammation.

MRI Thoracic Spine Without IV Contrast. MRI thoracic spine without IV contrast may be useful as an initial study in this group due to its excellent soft tissue resolution, particularly if there is concern for soft tissue or neurologic compressive injury, to identify a compression fracture (even if radiographs are negative), or to plan intervention (identify marrow edema) [36].

Radiography Thoracic Spine. Radiography may be useful as an initial screening study in TBP with risk factors for osteoporotic fractures in patients without neurologic deficits [35]. However, it should be noted that thoracic vertebral body fractures seen on radiographs may be difficult to estimate in terms of chronicity without priors to compare to. In those cases, MRI or bone scan may be needed to age the fracture acuity.

Variant 5: Adult. Thoracic back pain without or with myelopathy or radiculopathy. One or more of the following: suspicion of cancer, infection, or immunosuppression. Initial imaging

In patients with TBP and red flag symptoms or a known history of cancer, infection, or immunosuppression,

imaging plays an important role in identifying actionable and treatable causes of the patient's symptoms. In particular, imaging is useful for diagnosing the absence or presence of infection or neoplasm and its associated complications such as osseous destruction, change in alignment, and spinal canal or paraspinal soft tissue abscesses. The presence or absence of canal stenosis and cord compression or cord signal abnormality can also be important to identify in these patients.

Bone Scan Whole Body. There is no relevant literature to support the use of whole-body bone scan in the initial imaging assessment of this group.

Bone Scan With SPECT or SPECT/CT Thoracic Spine. There is no relevant literature to support the use of bone scans with SPECT or SPECT/CT in the initial imaging assessment of this group.

CT Myelography Thoracic Spine. CT myelography of the thoracic spine may be helpful in patients or for treatment planning (surgery, radiation).

CT Thoracic Spine With IV Contrast. There is no relevant literature to support the use of CT thoracic spine with IV contrast in the initial imaging assessment of this group.

CT Thoracic Spine Without and With IV Contrast. There is no relevant literature to support the use of CT thoracic spine without and with IV contrast in the initial imaging assessment of this group.

CT Thoracic Spine Without IV Contrast. CT thoracic spine without IV contrast may be helpful for presurgical planning or to delineate the osseous anatomy, particularly if there is osseous destruction [37].

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT skull base to mid-thigh in the initial imaging assessment of this group.

MRI Thoracic Spine With IV Contrast. MRI thoracic spine with IV contrast is not typically performed independently as an initial study, because its interpretation is most informative when correlated with standard noncontrast sequences included in MRI thoracic spine with and without IV contrast.

MRI Thoracic Spine Without and With IV Contrast. MRI without and with IV contrast is the initial imaging modality of choice in patients with TBP and suspected neoplasm or infection [36,38–42].

MRI Thoracic Spine Without IV Contrast. MRI without IV contrast may be useful in this setting to identify marrow replacing lesions, osseous destruction, canal

compromise, and cord signal abnormality. However, the addition of postcontrast sequences would be more sensitive in identifying thoracic spinal infection and its complications, assessing small marrow replacing lesions, and identifying intradural disease [39-44].

Radiography Thoracic Spine. Radiographs have low sensitivity but may be useful in the urgent/emergent setting to identify osseous destruction or change in alignment in patients with TBP and suspected infection or neoplasm [45].

Variant 6: Adult. Thoracic back pain without or with myelopathy or radiculopathy. Radiograph shows bone destruction or fracture or spinal deformity. Next imaging study

In patients with TBP and osseous destruction or spinal deformity the role of imaging is to delineate osseous detail and anatomy and assess the integrity of the soft tissue and neural structures, particularly that of the spinal canal. Additionally, if spinal hardware is present, assessing hardware integrity and position is also a common indication for imaging. More than one imaging modality may be indicated for diagnosis and treatment planning.

Bone Scan Whole Body. There is no relevant literature to support the use of whole body bone scans in the initial imaging assessment of this group.

Bone Scan With SPECT or SPECT/CT Thoracic Spine. There is no relevant literature to support the use of bone scan with SPECT or SPECT/CT in the initial imaging assessment of this group.

CT Myelography Thoracic Spine. CT myelography may be useful in this setting in patients with spinal hardware.

CT Thoracic Spine With IV Contrast. There is no relevant literature to support the use of CT thoracic spine with IV contrast in the initial imaging assessment of this group.

CT Thoracic Spine Without and With IV Contrast. CT thoracic spine without and with IV contrast may be useful in this clinical scenario.

CT Thoracic Spine Without IV Contrast. In patients with TBP with or without myelopathy or radiculopathy when there is evidence of osseous destruction or spinal deformity on radiographs, both MRI and CT may be useful as an initial imaging modality [11,46]. CT can better depict the osseous detail, and MRI is more useful for assessing the integrity of the soft tissue and neural structures, particularly that of the spinal canal.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT skull base to mid-thigh in the initial imaging assessment of this group.

MRI Thoracic Spine With IV Contrast. MRI thoracic spine with IV contrast is not typically performed independently as an initial study, because its interpretation is most informative when correlated with standard noncontrast sequences included in MRI thoracic spine with and without IV contrast.

MRI Thoracic Spine Without and With IV Contrast. MRI thoracic spine without and with IV contrast may be useful as an imaging study in patients with TBP and evidence of spinal deformity or osseous destruction on radiography, particularly if there is concern for infection or neoplasm [44].

MRI Thoracic Spine Without IV Contrast. MRI without IV contrast may be useful in this setting to identify marrow replacing lesions, osseous destruction, canal compromise, and cord signal abnormality [27]. However, the addition of postcontrast sequences would be more sensitive in identifying thoracic spinal infection and its complications, assessing small marrow replacing lesions, and identifying intradural disease.

Variant 7: Adult. Thoracic back pain without or with myelopathy or radiculopathy. Post thoracic spine surgery. Follow-up imaging

In patients with TBP and a history of spinal fixation, imaging plays an important role in assessing hardware position and integrity, assessing spinal alignment, assessing fusion, identifying findings suspicious for infection, and assessing for postoperative complications, including, but not limited to, postoperative collections, scarring, adjacent segment degeneration, and spinal deformity [47].

Several imaging modalities may be useful and complementary in the initial assessment of patients with TBP and a history of instrumented spinal fixation [43,45,47].

Bone Scan Whole Body. There is no relevant literature to support the use of whole-body bone scans in the initial imaging assessment of this group.

Bone Scan With SPECT or SPECT/CT Thoracic Spine. There is limited literature to support the use of bone scan with SPECT or SPECT/CT thoracic spine in the initial imaging assessment of this group.

CT Myelography Thoracic Spine. CT myelography may also be helpful in patients in whom a compressive etiology of their symptoms is clinically suspected.

CT Thoracic Spine With IV Contrast. There is no relevant literature to support the use of CT thoracic spine with IV contrast in the initial imaging assessment of this group.

CT Thoracic Spine Without and With IV Contrast. There is no relevant literature to support the use of CT thoracic spine without and with IV contrast in the initial imaging assessment of this group.

CT Thoracic Spine Without IV Contrast. CT thoracic spine without IV contrast may be useful in assessing the integrity of fusion, identifying hardware position and integrity, and assessing alignment.

FDG-PET/CT Skull Base to Mid-Thigh. There is no relevant literature to support the use of FDG-PET/CT skull base to mid-thigh in the initial imaging assessment of this group.

MRI Thoracic Spine With IV Contrast. MRI thoracic spine with IV contrast is not typically performed independently as an initial study, because its interpretation is most informative when correlated with standard noncontrast sequences included in MRI thoracic spine with and without IV contrast.

MRI Thoracic Spine Without and With IV Contrast. MRI thoracic spine without and with IV contrast may be helpful in assessing for postoperative infection, hematoma, postoperative collections, or canal compromise. Many of these patients may benefit from scanning on mid field or 1.5T MRI scanners with metallic susceptibility artifact reduction protocols [46,47].

MRI Thoracic Spine Without IV Contrast. MRI thoracic spine without IV contrast may help assess for postoperative hematoma or other collections, neurologic injury, residual foramina or canal stenosis, or cord compression.

Radiography Thoracic Spine. Radiographs may be useful for assessing the integrity of fusion, confirming hardware position and integrity, identifying adjacent level degeneration, and assessing alignment.

SUMMARY OF HIGHLIGHTS

- **Variant 1:** In an adult with acute TBP without myelopathy, radiculopathy, or red flags, imaging is not typically indicated. There is a lack of evidence supporting or refuting imaging early or before conservative treatment for TBP. However, extrapolating from the LBP evidence, imaging is typically not warranted in this setting.

- **Variant 2:** In an adult with subacute or chronic TBP without myelopathy, radiculopathy, or red flags, imaging is not typically indicated. As with acute TBP, few studies support or refute imaging for patients with subacute or chronic mid back pain without neurologic symptoms. However, as with LBP, imaging is typically not considered useful in this setting, but radiography of the thoracic spine may be appropriate.

- **Variant 3:** In an adult with TBP with myelopathy or radiculopathy, an MRI of the thoracic spine without IV contrast is usually appropriate for initial imaging. This modality allows for evaluating potential compressive etiologies upon the spinal cord, leading to myelopathy, or upon the nerve roots, leading to radiculopathy. In some cases, thoracic spine radiography, MRI of the thoracic spine without and with IV contrast, CT of the thoracic spine without IV contrast, and CT myelography of the thoracic spine may be appropriate.

- **Variant 4:** In an adult with TBP with one or more of the following low-velocity trauma, osteoporosis, advanced age, or chronic steroid use, thoracic spine radiography or MRI or CT of the thoracic spine without IV contrast is usually appropriate. Elderly (>65 years of age) individuals, those with known osteoporosis, prior benign nontraumatic compression fracture, or chronic steroid use are at risk for additional compression fractures even with minimal to no trauma. In this scenario, an MRI of the thoracic spine without and with IV contrast, whole body bone scan, and bone scan with SPECT or SPECT/CT may be appropriate for initial imaging.

- **Variant 5:** In an adult with suspicion of cancer, infection, or immunosuppression who is experiencing TBP, either an MRI of the thoracic spine without and with IV contrast or an MRI of the thoracic spine without IV contrast is usually appropriate for initial imaging. These modalities are useful for diagnosing the absence or presence of infection or neoplasm and its associated complications, such as osseous destruction, change in alignment, and spinal canal or paraspinal soft tissue abscesses. In some cases, thoracic spine radiography, CT of the thoracic spine without IV contrast, and CT myelography of the thoracic spine may be appropriate.

- **Variant 6:** In an adult whose radiograph shows bone destruction or fracture or spinal deformity, an MRI of the thoracic spine, either with and without IV contrast or without IV contrast, is usually appropriate

as the next imaging study. In addition, a CT of the thoracic spine without IV contrast is usually appropriate for the next imaging study because more than one imaging modality may be indicated for diagnosis and treatment planning. In some cases, CT myelography of the thoracic spine may be appropriate in this scenario.

■ **Variant 7:** In an adult with instrumented spinal fixation history, several imaging modalities may be useful and complementary in assessing patients with TBP. Imaging plays an important role in assessing hardware position and integrity, assessing spinal alignment, assessing fusion, identifying findings suspicious for infection, and assessing for postoperative complications. In this scenario, an MRI of the thoracic spine, either with and without IV contrast or without IV contrast, CT of the thoracic spine without IV contrast, or thoracic spine radiography is usually appropriate as the next imaging study. In some cases, CT myelography of the thoracic spine may be appropriate in this scenario.

SUPPORTING DOCUMENTS

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

RELATIVE RADIATION LEVEL INFORMATION

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see [Table 2](#)). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness

Criteria® Radiation Dose Assessment Introduction document [48].

REFERENCES

1. Johnson SM, Shah LM. Imaging of acute low back pain. *Radiol Clin North Am* 2019;57:397-413.
2. Murray CJ, Lopez AD. Measuring the global burden of disease. *N Engl J Med* 2013;369:448-57.
3. Briggs AM, Smith AJ, Straker LM, Bragge P. Thoracic spine pain in the general population: prevalence, incidence and associated factors in children, adolescents and adults. A systematic review. *BMC Musculoskelet Disord* 2009;10:77.
4. Institute for Clinical Systems Improvement. Adult acute and subacute low back pain. Available at: <https://www.icsi.org/guideline/low-back-pain/>. Accessed March 29, 2024.
5. Chou R, Qaseem A, Owens DK, Shekelle P. Clinical Guidelines Committee of the American College of Physicians. Diagnostic imaging for low back pain: advice for high-value health care from the American College of Physicians. *Ann Intern Med* 2011;154:181-9.
6. Jarvik JG, Gold LS, Comstock BA, et al. Association of early imaging for back pain with clinical outcomes in older adults. *JAMA* 2015;313:1143-53.
7. Jarvik JG, Hollingworth W, Martin B, et al. Rapid magnetic resonance imaging vs radiographs for patients with low back pain: a randomized controlled trial. *JAMA* 2003;289:2810-8.
8. Modic MT, Obuchowski NA, Ross JS, et al. Acute low back pain and radiculopathy: MR imaging findings and their prognostic role and effect on outcome. *Radiology* 2005;237:597-604.
9. AHCPR Publication No. 95-0642. Rockville, MD: Agency for Health Care Policy and Research, Public Health Service, US Department of Health and Human Services. Available at: <http://d4c2.com/d4c2-000038.htm>. Published December 1994. Accessed March 29, 2024.
10. Finucane LM, Downie A, Mercer C, et al. International framework for red flags for potential serious spinal pathologies. *J Orthop Sports Phys Ther* 2020;50:350-72.
11. Epstein O, Ludwig S, Gelb D, Poelstra K, O'Brien J. Comparison of computed tomography and plain radiography in assessing traumatic spinal deformity. *J Spinal Disord Tech* 2009;22:197-201.
12. Khurana B, Sheehan SE, Sodickson A, Bono CM, Harris MB. Traumatic thoracolumbar spine injuries: what the spine surgeon wants to know. *Radiographics* 2013;33:2031-46.
13. Rajasekaran S, Vaccaro AR, Kanna RM, et al. The value of CT and MRI in the classification and surgical decision-making among spine surgeons in thoracolumbar spinal injuries. *Eur Spine J* 2017;26:1463-9.
14. Splendiani A, Bruno F, Patriarca L, et al. Thoracic spine trauma: advanced imaging modality. *Radiol Med* 2016;121:780-92.
15. Marinova M, Edon B, Wolter K, Katsimbiri B, Schild HH, Strunk HM. Use of routine thoracic and abdominal computed tomography scans for assessing bone mineral density and detecting osteoporosis. *Curr Med Res Opin* 2015;31:1871-81.
16. Wang P, She W, Mao Z, et al. Use of routine computed tomography scans for detecting osteoporosis in thoracolumbar vertebral bodies. *Skeletal Radiol* 2021;50:371-9.
17. Zou D, Ye K, Tian Y, et al. Characteristics of vertebral CT Hounsfield units in elderly patients with acute vertebral fragility fractures. *Eur Spine J* 2020;29:1092-7.
18. National Center for Health S. Osteoporosis or low bone mass at the femur neck or lumbar spine in older adults, United States, 2005-2008. In: U.S. Dept. of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics 2012.
19. Cuzcman GJ, Mandell JC, et al. Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria(R) Inflammatory back pain: known or suspected axial spondyloarthritis: 2021 Update. *J Am Coll Radiol* 2021;18:S340-60.

20. Elliott JM, Flynn TW, Al-Najjar A, Press J, Nguyen B, Noteboom JT. The pearls and pitfalls of magnetic resonance imaging for the spine. *J Orthop Sports Phys Ther* 2011;41:848-60.
21. McInerney J, Ball PA. The pathophysiology of thoracic disc disease. *Neurosurg Focus* 2000;9:e1.
22. Wood KB, Garvey TA, Gundry C, Heithoff KB. Magnetic resonance imaging of the thoracic spine. Evaluation of asymptomatic individuals. *J Bone Joint Surg Am* 1995;77:1631-8.
23. Verdoorn JT, Lehman VT, Diehn FE, Maus TP. Increased 99mTc MDP activity in the costovertebral and costotransverse joints on SPECT-CT: is it predictive of associated back pain or response to percutaneous treatment? *Diagn Interv Radiol* 2015;21:342-7.
24. Awwad EE, Martin DS, Smith KR Jr, Baker BK. Asymptomatic versus symptomatic herniated thoracic discs: their frequency and characteristics as detected by computed tomography after myelography. *Neurosurgery* 1991;28:180-6.
25. Last AR, Hulbert K. Chronic low back pain: evaluation and management. *Am Fam Physician* 2009;79:1067-74.
26. Winklhofer S, Thekkumthala-Sommer M, Schmidt D, et al. Magnetic resonance imaging frequently changes classification of acute traumatic thoracolumbar spine injuries. *Skeletal Radiol* 2013;42:779-86.
27. Hurley P, Azzopardi C, Botchu R, Grainger M, Gardner A. Can MRI be used as a safe and expedient option for calculating Spinal Instability Neoplastic Score for patients with metastatic spinal cord compression? *Bone Joint J* 2021;103-B:971-5.
28. Laxpati N, Malcolm JG, Tsemo GB, et al. Spinal arachnoid webs: presentation, natural history, and outcomes in 38 patients. *Neurosurgery* 2021;89:917-27.
29. Chen ZQ, Sun CG, the Spine Surgery Group of Chinese Orthopedic Association. Clinical guideline for treatment of symptomatic thoracic spinal stenosis. *Orthop Surg* 2015;7:208-12.
30. Stillerman CB, Chen TC, Couldwell WT, Zhang W, Weiss MH. Experience in the surgical management of 82 symptomatic herniated thoracic discs and review of the literature. *J Neurosurg* 1998;88: 623-33.
31. Brown CW, Deffer PA Jr, Akmakjian J, Donaldson DH, Brugman JL. The natural history of thoracic disc herniation. *Spine (Phila Pa 1976)* 1992;17:S97-102.
32. Schultz R Jr, Steven A, Wessell A, et al. Differentiation of idiopathic spinal cord herniation from dorsal arachnoid webs on MRI and CT myelography. *J Neurosurg Spine* 2017;26:754-9.
33. Li Z, Chen YA, Chow D, Talbott J, Glastonbury C, Shah V. Practical applications of CISS MRI in spine imaging. *Eur J Radiol Open* 2019;6:231-42.
34. Yu JS, Krishna NG, et al, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria(R) Osteoporosis and bone mineral density: 2022 update. *J Am Coll Radiol* 2022;19:S417-32.
35. Khan MA, et al, Expert Panels on Neurological Imaging, Interventional Radiology, and Musculoskeletal Imaging. ACR Appropriateness Criteria(R) Management of vertebral compression fractures: 2022 update. *J Am Coll Radiol* 2023;20:S102-24.
36. Ramachandran S, Clifton IJ, Collyns TA, Watson JP, Pearson SB. The treatment of spinal tuberculosis: a retrospective study. *Int J Tuberc Lung Dis* 2005;9:541-4.
37. Liu JB, Zuo R, Zheng WJ, Li CQ, Zhang C, Zhou Y. The accuracy and effectiveness of automatic pedicle screw trajectory planning based on computer tomography values: an in vitro osteoporosis model study. *BMC Musculoskelet Disord* 2022;23:165.
38. Algra PR, Bloem JL, Tissing H, Falke TH, Arndt JW, Verboom LJ. Detection of vertebral metastases: comparison between MR imaging and bone scintigraphy. *Radiographics* 1991;11:219-32.
39. Bredella MA, Essary B, Torriani M, Ouellette HA, Palmer WE. Use of FDG-PET in differentiating benign from malignant compression fractures. *Skeletal Radiol* 2008;37:405-13.
40. Hong SH, Choi JY, Lee JW, Kim NR, Choi JA, Kang HS. MR imaging assessment of the spine: infection or an imitation? *Radiographics* 2009;29:599-612.
41. Shah LM, Salzman KL. Imaging of spinal metastatic disease. *Int J Surg Oncol* 2011;2011:769753.
42. Chantry A, Kazmi M, Barrington S, et al. Guidelines for the use of imaging in the management of patients with myeloma. *Br J Haematol* 2017;178:380-93.
43. Afolayan JO, Shafafy R, Maher M, Moon KH, Panchmatia JR. Assessment and management of adult spinal deformities. *Br J Hosp Med (Lond)* 2018;79:79-85.
44. Kim YH, Kim J, Chang SY, Kim H, Chang BS. Treatment strategy for impending instability in spinal metastases. *Clin Orthop Surg* 2020;12: 337-42.
45. Greif DN, Ghasem A, Butler A, Rivera S, Al Maaieh M, Conway SA. Multidisciplinary management of spinal metastasis and vertebral instability: a systematic review. *World Neurosurg* 2019;128:e944-55.
46. Zhu S, Wang Y, Yin P, Su Q. A systematic review of surgical procedures on thoracic myelopathy. *J Orthop Surg Res* 2020;15:595.
47. Kato S. Complications of thoracic spine surgery—their avoidance and management. *J Clin Neurosci* 2020;81:12-7.
48. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf>. Accessed March 29, 2024.