American College of Radiology
ACR Appropriateness Criteria®
Back Pain–Child

<u>Variant 1:</u> **Child. Back pain with none of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Initial imaging evaluation.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray spine area of interest	2	See references [1,4-6,8,9,11,12,21].	Varies
MRI complete spine without IV contrast	1	See references [1,4,5].	O
MRI complete spine with IV contrast	1		O
MRI complete spine without and with IV contrast	1	See references [8,27,28].	O
CT spine area of interest without IV contrast	1		Varies
CT spine area of interest with IV contrast	1		Varies
CT spine area of interest without and with IV contrast	1		Varies
Bone scan whole body with SPECT or SPECT/CT complete spine	1		☢☢☢☢
CT myelography complete spine	1		☢☢☢☢
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

<u>Variant 2:</u> **Child. Back pain with 1 or more of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Initial imaging evaluation.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray spine area of interest	8	See references [1,4-6,9].	Varies
MRI complete spine without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. This procedure is useful if neurologic symptoms are present. See references [1,4,5,8,24-26,32,34,35].	O
MRI complete spine without and with IV contrast	4	This procedure is useful if there is concern for inflammation, infection, or neoplasm. See variant 6. See references [8,15,28,33].	O
CT spine area of interest without IV contrast	3	See references [4,7,15,30,42].	Varies
CT spine area of interest with IV contrast	2		Varies
Bone scan whole body with SPECT or SPECT/CT complete spine	2	See references [4,19,20].	☢☢☢☢
MRI complete spine with IV contrast	1		O
CT spine area of interest without and with IV contrast	1		Varies
CT myelography complete spine	1		☢☢☢☢
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

<u>Variant 3:</u> **Child. Back pain with 1 or more of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Negative radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
MRI complete spine without IV contrast	8	See references [4,19,20].	O
MRI complete spine without and with IV contrast	6	This procedure is useful if there is concern for inflammation, infection, or neoplasm. See variant 6. See references [8,15,28,33].	O
CT spine area of interest without IV contrast	5	This procedure is useful to evaluate bony lesion. See references [8,15,28,33].	Varies
Bone scan whole body with SPECT or SPECT/CT complete spine	5	This procedure is useful for detection and characterization of pars injury. See references [8,15,28,33].	☢☢☢☢
CT spine area of interest with IV contrast	2		Varies
MRI complete spine with IV contrast	1		O
CT spine area of interest without and with IV contrast	1		Varies
CT myelography complete spine	1		☢☢☢☢
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 4: **Child. Back pain with 1 or more of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Positive radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
MRI complete spine without IV contrast	8	See references [8,15,28,33].	O
MRI complete spine without and with IV contrast	8	See references [8,15,28,33].	O
CT spine area of interest without IV contrast	5	This procedure is useful to evaluate bony lesions. See references [8,15,28,33].	Varies
Bone scan whole body with SPECT or SPECT/CT complete spine	4	This procedure is an alternative to MRI spine without IV contrast for diagnosis and characterization of spondylolysis spectrum. It does not consider the addition of CT. See references [8,15,28,33].	☢☢☢☢
CT spine area of interest with IV contrast	3		Varies
MRI complete spine with IV contrast	1		O
CT spine area of interest without and with IV contrast	1		Varies
CT myelography complete spine	1		☢☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Variant 5: **Child. Chronic back pain associated with overuse. Mechanical back pain.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray spine area of interest	9	See references [6,21,24,31].	Varies
MRI spine area of interest without IV contrast	7	This procedure is complementary for additional site involvement or negative radiographs. See references [6,8,21-24,37-40,42].	O
CT spine area of interest without IV contrast	6	This procedure is useful to evaluate bony lesions. See references [6,15,23,30,31,42].	Varies
Bone scan whole body with SPECT or SPECT/CT complete spine	6	This procedure is an alternative to MRI spine without IV contrast for diagnosis and characterization of spondylolysis spectrum. It does not consider the addition of CT. See references [6,19,20,30,31,36,42-44].	☢☢☢☢
MRI spine area of interest without and with IV contrast	3	See references [8,15,28,33].	O
MRI spine area of interest with IV contrast	1		O
CT spine area of interest with IV contrast	1		Varies
CT spine area of interest without and with IV contrast	1		Varies
CT myelography complete spine	1		☢☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

<u>Variant 6:</u> **Child. Back pain associated with suspected inflammation, infection, or malignancy.**

Radiologic Procedure	Rating	Comments	RRL*
MRI complete spine without and with IV contrast	9	See references [8,13,27-29,33].	O
X-ray complete spine	8	See references [7,8,27,28].	☢☢☢
MRI complete spine without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
CT spine area of interest without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. This procedure is useful to evaluate bony lesions.	Varies
Bone scan whole body with SPECT or SPECT/CT complete spine	4	This procedure is useful if multiple osseous lesions are suspected. It does not consider the addition of CT. See references [7,8,20].	☢☢☢☢
MRI complete spine with IV contrast	3		O
CT spine area of interest with IV contrast	3	See reference [7].	Varies
CT spine area of interest without and with IV contrast	2		Varies
CT myelography complete spine	1		☢☢☢☢
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

BACK PAIN–CHILD

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Summary of Literature Review

Introduction/Background

It is now generally accepted that nontraumatic back pain in the pediatric population is common. Evaluation of the spine in the setting of trauma will be addressed with a forthcoming ACR Appropriateness Criteria guideline. Early studies have reported prevalence as low as 2%, with more recent evidence suggesting that up to half of the pediatric population experiences back pain [1]. The incidence of back pain increases throughout childhood, most notably lower back pain [2]. Childhood back pain may be predictive of adult back pain [2]. Female sex, poor general health, high level of activity, backpack loads, and family history of back pain are risk factors that have been suggested [3]. Most pediatric back pain is mechanical and responds to conservative treatment with imaging not required in the clinical evaluation [1,4-6]. However, back pain may be caused by more serious conditions, including the broad categories of traumatic, infectious, inflammatory, congenital, and neoplastic processes [7,8]. Evaluation of scoliosis associated with pain will be addressed under a separate ACR Appropriateness Criteria guideline. Back pain is common in the pediatric athlete, with many potential etiologies [9].

The presence of isolated back pain in a child has previously been an indication for imaging; however, recently a more conservative approach has been suggested. As in adults, a diagnostic algorithm is suggested for evaluation of children with back pain in order to reduce the number of unnecessary examinations performed and resultant radiation exposure [10]. Children with back pain of short duration, a normal physical examination, and minor or no history of trauma will likely benefit little from further laboratory or imaging evaluation [1,8,11]. Imaging should be reserved for the presence of persistent back pain with concerning clinical and laboratory findings. Laboratory evaluation with a complete blood count and sedimentation rate may be of use to evaluate for a systemic etiology [12-14]. Clinical and laboratory findings suggesting an infectious or neoplastic etiology should be imaged without delay. The presence of constant pain, night pain, and radicular pain, alone or in combination, lasting for 4 weeks or more, constitute clinical red flags that should prompt further imaging. An abnormal neurologic examination should prompt immediate imaging [1,4,5].

Overview of Imaging Modalities

Radiographs

Radiographs of the symptomatic region are a useful initial imaging modality, as they are readily available and may lead to a diagnosis in a significant number of patients [4]. Vertebral alignment, spinal curvature, and disc height can easily be ascertained using radiographs. The presence of spondylolysis, Scheuermann disease, and primary bone tumors may be suggested on radiographs and direct any further imaging [4,15,16]. Oblique views of the lumbar spine have been shown to double the radiation dose delivered without any additional helpful information beyond the standard frontal and lateral views [6,9]. Radiographs are insensitive to paraspinal and intraspinal soft-tissue masses.

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Bone Scan Whole Body with SPECT or SPECT/CT Complete Spine

Back pain can be difficult to localize in children. The ability of Tc-99m whole-body bone scan to evaluate the entire axial skeleton as well as identify potential multifocal disease is an advantage of this modality [17]. The addition of single-photon emission computed tomography (SPECT) increases the sensitivity and specificity of the examination and has been shown to improve the detection of spondylolysis [18]. SPECT bone scan has been shown to be superior to magnetic resonance imaging (MRI) in detecting active spondylolysis [19] and several authors support SPECT bone scan over MRI in the evaluation of spondylolysis [7,9,12]. The SPECT bone scan is moderately sensitive in evaluation of infection and tumor, but additional imaging is typically needed for diagnosis and management [20]. Screening SPECT bone scan may have increased sensitivity in cases of back pain with shorter duration of symptoms [21].

Magnetic Resonance Imaging

MRI without contrast has been shown to be an effective screening tool in evaluating pediatric patients with certain red-flag clinical presentations [1,5]. In young patients, the MRI examination may need to be performed under sedation. MRI is the only modality that directly visualizes the spinal cord, ligaments, and intervertebral discs. T2-weighted images and fat-suppression techniques are necessary for evaluating for marrow edema and paraspinal pathology. MRI without contrast is often able to determine a cause of mechanical back pain, most commonly spondylolysis, with high sensitivity [22-24]. Recent studies have demonstrated MRI to be more sensitive than computed tomography (CT) and a potential first-line test in the evaluation of spondylolysis [23,24]. Fluid-sensitive and fat-suppressed MRI techniques are able to identify stress reaction (marrow edema) in the pedicles as well as spondylolisthesis, which are the 2 findings that guide management of these patients [22,24]. MRI is optimal for demonstrating degenerative disc pathology, which may be more common in the pediatric population than previously suspected [25,26].

The main advantage of MRI is optimal intraspinal and paraspinal soft-tissue evaluation. Intraspinal tumors can present with back pain and MRI is the indicated imaging modality in this subset of patients [27,28]. Osteomyelitis and epidural and paraspinal infection are well demonstrated on MRI and can guide surgical intervention [13,14,29]. Fat-suppressed T2 and T1 postcontrast MRI sequences such as short tau inversion recovery, Dixon, and fat-suppressed turbo spin echo are necessary for evaluation of suspected infectious or neoplastic disease involving the vertebrae, discs, or paraspinous soft tissues [8].

Computed Tomography

CT without contrast provides excellent bone detail. The modality is suboptimal for evaluating the intraspinal contents and the paraspinal soft tissues in comparison with MRI. The ability of CT to reconstruct in multiple planes and perform 3D volume-rendered images is an advantage. CT targeted to the area of interest can be useful in the evaluation of suspected spondylolysis as well as primary bone tumors such as osteoid osteoma, osteoblastoma, and aneurysmal bone cyst [15,27,30]. However, CT does not demonstrate associated marrow edema. Also, intrinsic fluid-fluid levels and associated soft-tissue abnormalities are better demonstrated on MRI. Apophyseal ring fractures are also well evaluated on CT [31]. CT with contrast can be considered when infection and abscess are suspected and MRI is contraindicated or not feasible.

Myelography and Postmyelography Computed Tomography Spine

The indication for myelography and postmyelography CT is narrow and limited because of its invasiveness and limited diagnostic yield. Myelography and postmyelography CT can be considered in conditions where intraspinal pathology is suspected and MRI is either contraindicated or will be significantly limited by existing hardware.

Discussion of Imaging Modalities by Variant

Variant 1: Child. Back pain with none of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Initial imaging evaluation.

Radiographs

There is little evidence that radiographic evaluation of the region of interest in acute uncomplicated back pain without an associated traumatic event is indicated [8,9,11,12].

MRI Spine

MRI is not indicated in back pain without clinical red flags present [1,4,5]. If an inflammatory, infectious, or neoplastic process is suggested from initial clinical or laboratory evaluation, MRI without and with contrast of the complete spine is the suggested imaging modality in further imaging evaluation [8,27,28]. If contrast is administered, precontrast images are helpful to assess enhancement. There is little use for performing an MRI with contrast only.

CT Spine
CT is not indicated for evaluation of patients with back pain and no clinical red flags. If an inflammatory, infectious, or neoplastic process is suggested from initial clinical or laboratory evaluation and MRI cannot be obtained, a CT spine with contrast targeted to the area of interest may be indicated. CT spine without and with contrast is not indicated for evaluation of patients with back pain and no red flags.

Bone Scan Whole Body with SPECT or SPECT/CT Complete Spine
SPECT bone scan is not indicated for evaluation of patients with back pain and no red flags.

Myelography and Postmyelography CT Spine
This examination is not indicated for evaluation of patients with back pain and no red flags.

Variant 2: Child. Back pain with 1 or more of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Initial imaging evaluation.

Radiographs
Radiographs of the cervical, thoracic, or lumbar spine are a useful initial diagnostic imaging procedure for evaluation of back pain in children. Radiographs can demonstrate findings that lead to the diagnosis in up to 24% of children [1,4,5]. Anterior-posterior radiographs are typically sufficient, with additional views only adding to the radiation dose without increase in diagnostic yield. Collimation to the area of concern may aid in the diagnosis [6,9]. Pathologic conditions that can be diagnosed on radiographs include spondylolysis, scoliosis, Scheuermann disease, and bone tumors [1,4,5]. In children with back pain and clinical red flags, negative radiographs are not considered adequate to exclude pathology and additional advanced imaging techniques are required [1,5]. Positive radiographs leading to a specific diagnosis may guide therapy without additional imaging or direct further appropriate imaging evaluation [1,4,5].

MRI Spine
Noncontrast MRI of the spine targeted to the region of interest is sensitive for the imaging evaluation of soft-tissue and bony abnormalities associated with pediatric back pain, including paraspinous soft-tissue pathology, disc disease, marrow edema, and intraspinal masses [8,24-26,32]. However, radiographs should be the initial imaging evaluation in most cases. MRI of the total spine may be indicated as the initial evaluation of patients with abnormal neurologic findings. Contrast is helpful in the evaluation of back pain in children when there is clinical or laboratory evidence of infection, inflammation, or tumor [8,13,33]. If contrast is administered, precontrast images are helpful to assess enhancement. There is little use for performing an MRI with contrast only.

CT Spine
Bone lesions and fractures are well delineated on targeted noncontrast CT [7,15]. However, radiographs should be obtained initially. Although CT with contrast may be helpful when infection or tumor is suspected, MRI without and with contrast is the modality of choice in the evaluation of these patients. CT with contrast should be considered only when MRI is contraindicated or not feasible. CT both without and with contrast is not usually indicated. In the circumstance where there is a need to determine the presence of calcifications, limited noncontrast images could be obtained through the area of interest.

Bone Scan Whole Body with SPECT or SPECT/CT Complete Spine
Tc-99m bone scan may be a useful screening tool in children with back pain and no specific neurologic findings on physical examination [4]. However, radiographs should be the initial imaging examination and may direct further evaluation.

Myelography and Postmyelography CT Spine
Because of the invasiveness of the procedure, myelography and postmyelography CT of the whole spine are considered in the setting of an abnormal neurologic examination only if MRI is contraindicated or will have significantly limited diagnostic yield because of spinal hardware.

Variant 3: Child. Back pain with 1 or more of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Negative radiographs.

Children with negative radiographs and back pain associated with clinical red flags should undergo additional imaging evaluation.

MRI Spine
MRI of the total spine is sensitive for the imaging evaluation of soft-tissue and bony abnormalities associated with pediatric back pain, including paraspinous soft-tissue pathology, disc disease, marrow edema, and intraspinal masses [8,24-26,32]. Nonneoplastic intraspinal etiologies of back pain such as syrinx and meningoceles are well demonstrated using MRI [34,35]. Two large prospective studies have used MRI in an algorithm for evaluation of pediatric back pain in a total of 348 patients [1,5]. These studies found that MRI had high diagnostic accuracy in identifying and delineating the etiology of pediatric back pain. MRI is especially useful in evaluation of children with positive neurologic findings and should be considered the primary imaging modality in this subset of patients. An imaging algorithm has been proposed that includes only MRI in the imaging evaluation of children with positive neurologic findings [4]. Contrast is helpful in the evaluation of back pain in children when there is clinical or laboratory evidence of infection, inflammation, or tumor [8,13,33]. If contrast is administered, precontrast images are helpful to assess enhancement. There is little use for performing an MRI with contrast only. MRI of the spine in the clinical setting of back pain should always be performed with fat-saturated imaging techniques, especially following the administration of contrast.

CT Spine
Fractures and bone lesions are well delineated on targeted noncontrast CT [7,15]. CT has been found to be complementary to bone scan in evaluation of spondylolysis [4,30].

CT with contrast can be used when infection or tumor is suspected; however, MRI without and with contrast is the modality of choice in the evaluation of these patients. CT with contrast targeted to the area of interest should be considered only when MRI is contraindicated or not feasible. Performing CT both without and with contrast is not usually indicated. In the circumstance of determining the presence of calcifications, limited images could be obtained through the area of interest.

Bone Scan Whole Body with SPECT or SPECT/CT Complete Spine
Tc-99m bone scan may be a useful tool in children with back pain and no specific neurologic findings on physical examination [4]. However, a retrospective study evaluating bone scan as a screening tool found that primary malignancies of the spine were missed in 3 out of 142 patients, although only planar bone scans were obtained in this study [20]. Although bone scan with SPECT can be very sensitive to bone pathology such as spondylolysis [19], potentially significant causes of back pain could be missed using only this modality [8,20]. SPECT/CT is not addressed in this discussion because it is not widely available.

Myelography and Postmyelography CT Spine
Because of the invasiveness of the procedure, myelography and postmyelography CT of the whole spine are considered in the setting of an abnormal neurologic examination only if MRI is contraindicated or will have significantly limited diagnostic yield because of spinal hardware.

Variant 4: Child. Back pain with 1 or more of the following clinical red flags: constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination. Positive radiographs.

MRI Spine
MRI is sensitive for the imaging evaluation of soft-tissue and bony abnormalities associated with pediatric back pain, including paraspinous soft-tissue pathology, disc disease, marrow edema, and intraspinal masses that may be suggested on radiographs of the spine [8,24-26,32]. Two large prospective studies have used MRI in an algorithm for evaluation of pediatric back pain in a total of 348 patients [1,5]. These studies found that MRI had high diagnostic accuracy in identifying and delineating the etiology of pediatric back pain; however, if a specific diagnosis was determined using spine radiographs, MRI was not performed. MRI can confirm and further characterize abnormalities demonstrated on radiographs. MRI is especially useful in evaluation of children with positive neurologic findings.

An imaging algorithm has been proposed that includes only MRI in the imaging evaluation of children with positive neurologic findings [4]. If contrast is administered, precontrast images are helpful to assess enhancement. Findings on spine radiographs such as disc-space narrowing, endplate irregularity, bone destruction, or widening of the spinal canal suggest an inflammatory, infectious, or neoplastic process [7,8]. MRI of the total spine without and with contrast is helpful in the evaluation of back pain in children with clinical or imaging evidence of infection, inflammation, or tumor [8,13,33]. There is little use for performing an MRI with contrast only. MRI of the spine in the clinical setting of back pain should always be performed with fat-saturated imaging techniques, especially following the administration of contrast.

CT Spine
Fractures and bone lesions may be suggested on radiographs of the spine. These entities may be better delineated and confirmed on targeted noncontrast CT [7,15]. CT has been found to be complementary to bone scan in evaluation of spondylolysis [4,30]. CT with contrast should be considered only when MRI is contraindicated or not feasible. Performing CT both without and with contrast is not usually indicated. In the circumstance of determining the presence of calcifications, limited noncontrast images could be obtained through the area of interest.

Bone Scan Whole Body with SPECT or SPECT/CT Complete Spine
Tc-99m bone scan may be a useful screening tool in children with back pain and no specific neurologic findings on physical examination [4]. Bone scan can confirm the presence of an abnormality suggested on radiographs, and because of the whole-body technique it has the ability to demonstrate additional osseous abnormalities (multifocality) as regions of increased radiotracer uptake [31,36]

Myelography and Postmyelography CT Spine
Because of the invasiveness of the procedure, myelography and postmyelography CT of the total spine are considered in the setting of an abnormal neurologic examination only if MRI is contraindicated or will have significantly limited diagnostic yield because of spinal hardware.

Variant 5: Child. Chronic back pain associated with overuse. Mechanical back pain.

Radiographs
The most common etiology for overuse-related chronic back pain in children is spondylolysis. Radiography of the symptomatic region of the spine is a useful screening tool for spondylolysis, with a sensitivity of 77.6% for anterior-posterior and lateral radiographs [6]. The combination of negative radiographs and a negative clinical examination was reported to have an 0.81 negative predictive value [21]. Additional views did not significantly increase sensitivity [6,9]. Other reports have suggested a lower sensitivity for diagnosing spondylolysis using radiographs as compared to MRI [24]. Other etiologies for chronic back pain, such as apophyseal ring fractures and Scheuermann disease, may be suggested with radiographs alone [31].

MRI Spine
MRI can show edema in the region of the pars interarticularis or adjacent pedicle in spondylolysis with negative radiographs and CT. MRI is especially useful in detection of active spondylolysis and has been positively associated with clinical symptomatology [23,24]. Resolution of signal abnormalities suggests a response to therapy and potential prevention of progression to fracture [22,37]. It remains uncertain whether MRI or bone scan with SPECT is preferred in the evaluation of suspected spondylolysis [38]. Abnormalities on MRI such as apophyseal injuries, spondylolysis, and disc disease have been shown to be associated with back pain in the pediatric athlete [39]. MRI can evaluate radiculopathy elicited by both spondylolytic and nonspondylolytic causes and may demonstrate additional etiologies, including apophyseal fractures, intraspinous ligamentous injury, discogenic injury, Scheuermann disease, and compartment syndromes [8,31,40]. If contrast is administered, precontrast images are needed to assess enhancement. MRI of the spine in the clinical setting of back pain should always be performed with fat-saturated imaging techniques. There is little use for performing an MRI with contrast only. Contrast is not indicated in the evaluation of chronic back pain due to suspected mechanical causes.

CT Spine
CT is mostly considered an adjunct to other imaging modalities and has a high sensitivity in evaluation of spondylolysis [6]. CT is superior to radiographs in evaluation of spondylolysis, and with radiation dose-reduction techniques, a similar dose can be achieved [41]. CT has been shown to be complementary in the evaluation of pars interarticularis injuries and has the potential to direct further management [30]. Early stress reaction may be missed using CT alone without a bone scan or MRI [23,42]. Ring apophyseal injuries are also well demonstrated on CT [15,31]. CT spine with contrast is not indicated in mechanical back pain.

Bone Scan Whole Body with SPECT or SPECT/CT Complete Spine
There have been studies that have shown that bone scan with SPECT is a sensitive imaging technique for the evaluation of suspected spondylolysis at all ages [6,43,44]. Bone scan has been shown to be more sensitive in comparison to MRI for evaluation of active spondylolysis [19]. However, MRI may be able to detect disc pathology and other processes that can mimic or be associated with spondylolysis [32,40]. In chronic spondylolysis with wide separation and smooth margins, the bone scan may be negative [30]. On the other hand, bone scan can demonstrate increased uptake due to a stress reaction while CT reveals no abnormality [42].

Because of the whole-body technique, bone scan can demonstrate additional osseous abnormalities as regions of increased radiotracer uptake [31,36].

Myelography and Postmyelography CT Spine
This examination is not indicated in the evaluation of chronic back pain due to suspected mechanical causes and normal neurologic examination.

Variant 6: Child. Back pain associated with suspected inflammation, infection, or malignancy.

Radiographs
Radiography of the area of clinical interest can be suggestive of inflammatory, infectious, or malignant conditions affecting the spine; however, the modality is insensitive and can easily miss subtle findings [27,28]. Discogenic infections occur in the pediatric population and manifest as mild disc-space narrowing on radiographs [7]. Lytic or sclerotic primary and metastatic tumors may be identified along with evidence of bony destruction, periosteal reaction, or a soft-tissue mass. Subtle pedicular erosion with widening of the interpedicular distance or enlargement of the neural foramina may be secondary findings due to an intraspinal tumor [8].

MRI Spine
If inflammation, infection, or malignancy is suspected, MRI without and with contrast of the total spine or region of interest is indicated. A noncontrast examination may be indicated in the presence of renal dysfunction. MRI is generally accepted as the primary imaging modality for the detection and evaluation of intra- and paraspinal masses [27,28]. The ability to localize the mass in relation to adjacent neural structures is a significant advantage over other imaging modalities [8]. Infectious spondyloarthropathies also are best imaged using MRI because of its ability to evaluate for epidural extension of disease and cord compromise [8,13,29]. MRI may also be able to differentiate tuberculous from nontuberculous spondylitis [14]. Additionally, inflammatory arthropathies are well evaluated with MRI [33]. If contrast is administered, precontrast images are needed to assess enhancement. There is little use for performing an MRI with contrast only. MRI of the spine in this clinical setting should always be performed with fat-saturated imaging techniques.

CT Spine
CT spine without contrast is not usually indicated in the evaluation of suspected infection or neoplasm. If there is a mass originating in bone, targeted CT may help to characterize the lesion. CT with contrast demonstrates paraspinal abscesses with high sensitivity and guides surgical management [29]. Associated bone destruction, sclerosis, and disc-space narrowing are well delineated, especially with orthogonal reconstructions [7]. Performing CT both without and with contrast is not usually indicated. In the circumstance where there is a need to determine the presence of calcifications, limited noncontrast images could be obtained through the area of interest.

Bone Scan Whole Body with SPECT or SPECT/CT Complete Spine
Bone scan will demonstrate primary osseous lesions and reactive changes but will not adequately evaluate paraspinal soft-tissue masses or intraspinal pathology [7,8,20,36].

Myelography and Postmyelography CT Spine
Because of the invasiveness of the procedure, this examination is considered indicated only if a positive neurologic examination is present and if MRI is contraindicated. It can also be considered if adequate diagnostic information cannot be obtained by contrast-enhanced spine CT.

Summary of Recommendations

- Imaging is not recommended in a child with back pain with no red flags (constant pain, night pain, radicular pain, pain lasting >4 weeks, abnormal neurologic examination).
- Spine radiographs are recommended in the initial evaluation of a child with back pain with red flags. They can provide a diagnosis and direct therapy.
- MRI spine without contrast is recommended for evaluation of a child with back pain with red flags and normal radiographs because of its ability to demonstrate soft-tissue detail and intraspinal structures. Contrast may be useful if there is concern for inflammation, infection, or neoplasm.
- MRI spine without intravenous (IV) contrast is recommended for evaluation of a child with back pain and positive radiographs for further characterization or to demonstrate additional abnormalities. Contrast is useful if there is concern for inflammation, infection, or neoplasm.

- Spine radiographs are recommended for evaluation of a child with chronic back pain associated with overuse (mechanical back pain). MRI spine without IV contrast is recommended to evaluate for additional site involvement or if radiographs do not demonstrate an abnormality.
- Spine radiographs and MRI spine without and with IV contrast are recommended for evaluation of a child with back pain associated with inflammation, infection, or malignancy.

Summary of Evidence

Of the 44 references cited in the *ACR Appropriateness Criteria® Back Pain–Child* document, 3 are categorized as therapeutic references, including 2 quality studies that may have design limitations. Additionally, 41 references are categorized as diagnostic references, including 1 well-designed study, 3 good-quality studies, and 13 quality studies that may have design limitations. There are 25 references that may not be useful as primary evidence.

The 44 references cited in the *ACR Appropriateness Criteria® Back Pain–Child* document were published from 1991 through 2015.

Although there are references that report on studies with design limitations, 4 well-designed or good-quality studies provide good evidence.

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, both because of 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 to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*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".

Supporting Documents

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

References

1. Ramirez N, Flynn JM, Hill BW, et al. Evaluation of a systematic approach to pediatric back pain: the utility of magnetic resonance imaging. *J Pediatr Orthop.* 2015;35(1):28-32.
2. Kjaer P, Wedderkopp N, Korsholm L, Leboeuf-Yde C. Prevalence and tracking of back pain from childhood to adolescence. *BMC Musculoskelet Disord.* 2011;12:98.

3. Shymon SJ, Yaszay B, Dwek JR, Proudfoot JA, Donohue M, Hargens AR. Altered disc compression in children with idiopathic low back pain: an upright magnetic resonance imaging backpack study. *Spine (Phila Pa 1976).* 2014;39(3):243-248.
4. Bhatia NN, Chow G, Timon SJ, Watts HG. Diagnostic modalities for the evaluation of pediatric back pain: a prospective study. *J Pediatr Orthop.* 2008;28(2):230-233.
5. Feldman DS, Straight JJ, Badra MI, Mohaideen A, Madan SS. Evaluation of an algorithmic approach to pediatric back pain. *J Pediatr Orthop.* 2006;26(3):353-357.
6. Miller R, Beck NA, Sampson NR, Zhu X, Flynn JM, Drummond D. Imaging modalities for low back pain in children: a review of spondyloysis and undiagnosed mechanical back pain. *J Pediatr Orthop.* 2013;33(3):282-288.
7. Khoury NJ, Hourani MH, Arabi MM, Abi-Fakher F, Haddad MC. Imaging of back pain in children and adolescents. *Curr Probl Diagn Radiol.* 2006;35(6):224-244.
8. Rodriguez DP, Poussaint TY. Imaging of back pain in children. *AJNR Am J Neuroradiol.* 2010;31(5):787-802.
9. Sucato DJ, Micheli LJ, Estes AR, Tolo VT. Spine problems in young athletes. *Instr Course Lect.* 2012;61:499-511.
10. Schlemmer E, Mitchiner JC, Brown M, Wasilevich E. Imaging during low back pain ED visits: a claims-based descriptive analysis. *Am J Emerg Med.* 2015;33(3):414-418.
11. Bernstein RM, Cozen H. Evaluation of back pain in children and adolescents. *Am Fam Physician.* 2007;76(11):1669-1676.
12. Haidar R, Saad S, Khoury NJ, Musharrafieh U. Practical approach to the child presenting with back pain. *Eur J Pediatr.* 2011;170(2):149-156.
13. Kempthorne JT, Pratt C, Smale EL, MacFarlane MR. Ten-year review of extradural spinal abscesses in a New Zealand tertiary referral centre. *J Clin Neurosci.* 2009;16(8):1038-1042.
14. Yee DK, Samartzis D, Wong YW, Luk KD, Cheung KM. Infective spondylitis in Southern Chinese: a descriptive and comparative study of ninety-one cases. *Spine (Phila Pa 1976).* 2010;35(6):635-641.
15. Altaf F, Heran MK, Wilson LF. Back pain in children and adolescents. *Bone Joint J.* 2014;96-B(6):717-723.
16. Summers BN, Singh JP, Manns RA. The radiological reporting of lumbar Scheuermann's disease: an unnecessary source of confusion amongst clinicians and patients. *Br J Radiol.* 2008;81(965):383-385.
17. Hospach T, Langendoerfer M, von Kalle T, Maier J, Dannecker GE. Spinal involvement in chronic recurrent multifocal osteomyelitis (CRMO) in childhood and effect of pamidronate. *Eur J Pediatr.* 2010;169(9):1105-1111.
18. Bellah RD, Summerville DA, Treves ST, Micheli LJ. Low-back pain in adolescent athletes: detection of stress injury to the pars interarticularis with SPECT. *Radiology.* 1991;180(2):509-512.
19. Masci L, Pike J, Malara F, Phillips B, Bennell K, Brukner P. Use of the one-legged hyperextension test and magnetic resonance imaging in the diagnosis of active spondylolysis. *Br J Sports Med.* 2006;40(11):940-946; discussion 946.
20. Sanpera I, Jr., Beguiristain-Gurpide JL. Bone scan as a screening tool in children and adolescents with back pain. *J Pediatr Orthop.* 2006;26(2):221-225.
21. Auerbach JD, Ahn J, Zgonis MH, Reddy SC, Ecker ML, Flynn JM. Streamlining the evaluation of low back pain in children. *Clin Orthop Relat Res.* 2008;466(8):1971-1977.
22. Cohen E, Stuecker RD. Magnetic resonance imaging in diagnosis and follow-up of impending spondylolysis in children and adolescents: early treatment may prevent pars defects. *J Pediatr Orthop B.* 2005;14(2):63-67.
23. Goda Y, Sakai T, Sakamaki T, Takata Y, Higashino K, Sairyo K. Analysis of MRI signal changes in the adjacent pedicle of adolescent patients with fresh lumbar spondylolysis. *Eur Spine J.* 2014;23(9):1892-1895.
24. Kobayashi A, Kobayashi T, Kato K, Higuchi H, Takagishi K. Diagnosis of radiographically occult lumbar spondylolysis in young athletes by magnetic resonance imaging. *Am J Sports Med.* 2013;41(1):169-176.
25. Kjaer P, Leboeuf-Yde C, Sorensen JS, Bendix T. An epidemiologic study of MRI and low back pain in 13-year-old children. *Spine (Phila Pa 1976).* 2005;30(7):798-806.
26. Ozgen S, Konya D, Toktas OZ, Dagcinar A, Ozek MM. Lumbar disc herniation in adolescence. *Pediatr Neurosurg.* 2007;43(2):77-81.
27. Garg S, Dormans JP. Tumors and tumor-like conditions of the spine in children. *J Am Acad Orthop Surg.* 2005;13(6):372-381.
28. Huisman TA. Pediatric tumors of the spine. *Cancer Imaging.* 2009;9 Spec No A:S45-48.

29. Dietrich A, Vaccarezza H, Vaccaro CA. Iliopsoas abscess: presentation, management, and outcomes. *Surg Laparosc Endosc Percutan Tech.* 2013;23(1):45-48.
30. Gregory PL, Batt ME, Kerslake RW, Scammell BE, Webb JF. The value of combining single photon emission computerised tomography and computerised tomography in the investigation of spondylolysis. *Eur Spine J.* 2004;13(6):503-509.
31. DePalma MJ, Bhargava A. Nonspondylolytic etiologies of lumbar pain in the young athlete. *Curr Sports Med Rep.* 2006;5(1):44-49.
32. Wang H, Cheng J, Xiao H, Li C, Zhou Y. Adolescent lumbar disc herniation: experience from a large minimally invasive treatment centre for lumbar degenerative disease in Chongqing, China. *Clin Neurol Neurosurg.* 2013;115(8):1415-1419.
33. Vendhan K, Sen D, Fisher C, Ioannou Y, Hall-Craggs MA. Inflammatory changes of the lumbar spine in children and adolescents with enthesitis-related arthritis: magnetic resonance imaging findings. *Arthritis Care Res (Hoboken).* 2014;66(1):40-46.
34. Joseph RN, Batty R, Raghavan A, Sinha S, Griffiths PD, Connolly DJ. Management of isolated syringomyelia in the paediatric population--a review of imaging and follow-up in a single centre. *Br J Neurosurg.* 2013;27(5):683-686.
35. Lohani S, Rodriguez DP, Lidov HG, Scott RM, Proctor MR. Intrasacral meningocele in the pediatric population. *J Neurosurg Pediatr.* 2013;11(6):615-622.
36. Lehman VT, Murphy RC, Maus TP. 99mTc-MDP SPECT/CT of the spine and sacrum at a multispecialty institution: clinical use, findings, and impact on patient management. *Nucl Med Commun.* 2013;34(11):1097-1106.
37. Borg B, Modic MT, Obuchowski N, Cheah G. Pedicle marrow signal hyperintensity on short tau inversion recovery- and t2-weighted images: prevalence and relationship to clinical symptoms. *AJNR Am J Neuroradiol.* 2011;32(9):1624-1631.
38. Kim HJ, Green DW. Spondylolysis in the adolescent athlete. *Curr Opin Pediatr.* 2011;23(1):68-72.
39. Bennett DL, Nassar L, DeLano MC. Lumbar spine MRI in the elite-level female gymnast with low back pain. *Skeletal Radiol.* 2006;35(7):503-509.
40. Sairyo K, Sakai T, Amari R, Yasui N. Causes of radiculopathy in young athletes with spondylolysis. *Am J Sports Med.* 2010;38(2):357-362.
41. Fadell MF, Gralla J, Bercha I, et al. CT outperforms radiographs at a comparable radiation dose in the assessment for spondylolysis. *Pediatr Radiol.* 2015;45(7):1026-1030.
42. Yang J, Servaes S, Edwards K, Zhuang H. Prevalence of stress reaction in the pars interarticularis in pediatric patients with new-onset lower back pain. *Clin Nucl Med.* 2013;38(2):110-114.
43. Spencer HT, Sokol LO, Glotzbecker MP, et al. Detection of pars injury by SPECT in patients younger than age 10 with low back pain. *J Pediatr Orthop.* 2013;33(4):383-388.
44. Takemitsu M, El Rassi G, Woratanarat P, Shah SA. Low back pain in pediatric athletes with unilateral tracer uptake at the pars interarticularis on single photon emission computed tomography. *Spine (Phila Pa 1976).* 2006;31(8):909-914.