AmeriHealth Caritas Louisiana

National Imaging Associates, Inc.*	
Clinical guidelines: **LUMBAR SPINE CT**	**Original Date: September 1997**
CPT Codes: 72131, 72132, 72133	**Last Revised Date: May 2020**
Guideline Number: NIA_CG_045	**Implementation Date: ~~January 2021~~TBD**

GENERAL INFORMATION:

It is an expectation that all patients receive care/services from a licensed clinician. All appropriate supporting documentation, including recent pertinent office visit notes, laboratory data, and results of any special testing must be provided. All prior relevant imaging results, and the reason that alternative imaging (gold standard, protocol, contrast, etc.) cannot be performed must be included in the documentation submitted.

INDICATIONS FOR LUMBAR SPINE CT:

For evaluation of ~~chronic~~ back pain with any of the following when Lumbar Spine MRI is contraindicated
(~~ACR, 2015;~~ AAFP, 2012; AANSCNS, 2014; ACA, 2017; ACEP, 2014; ACR, 2015; ~~NASS, 2013;~~ Chou, 2007; Jarvik, 2015; Last, 2009; NASS, 2013)

- **With new or worsening objective neurologic deficits on exam**
- **Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.**
- **With progression or worsening of symptoms during the course of conservative treatment*.**
- **With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a lumbar radiculopathy. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013)).**

~~For evaluation of new onset of back pain when Lumbar Spine MRI is contraindicated~~
~~(ACR, 2015; AANSCNS, 2014; ACA, 2017; ACEP, 2014; Chou, 2007)~~
~~With new or worsening objective neurologic deficits on exam~~
~~Failure of conservative treatment*, for at least six (6) weeks within the last six (6) months.~~
~~With progression or worsening of symptoms during the course of conservative treatment*.~~

*** National Imaging Associates, Inc. (NIA) is a subsidiary of Magellan Healthcare, Inc.**

~~With an abnormal electromyography (EMG) or nerve conduction study if (if performed) indicating a lumbar radiculopathy. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013))~~

For evaluation of neurologic deficits when Lumbar Spine MRI is contraindicated or inappropriate

- **With any of the following new neurological deficits: lower extremity muscular weakness; abnormal reflexes; abnormal sensory changes along a particular dermatome (nerve distribution) as documented on exam; evidence of Cauda Equina Syndrome; bowel or bladder dysfunction; new foot drop.**

For evaluation of known fracture

- To assess union of a fracture where physical examination, plain radiographs, or prior imaging suggests delayed or non-healing
- To determine position of known fracture fragments.

~~For evaluation of neurologic deficits when Lumbar Spine MRI is contraindicated or inappropriate~~

- ~~With any of the following new neurological deficits: lower extremity weakness; abnormal reflexes; abnormal sensory changes along a particular dermatome (nerve distribution) as documented on exam; evidence of Cauda Equina Syndrome; bowel or bladder dysfunction; new foot drop.~~

CT myelogram is indicated when signs and symptoms are incongruent with MRI findings or MRI cannot be ~~preformed~~performed/contraindicated (Grams, 2010; Morita, 2011; Naganawa, 2011; NASS, 2012; Ozdoba; 2011)

~~For evaluation of chronic back pain with any of the following when Lumbar Spine MRI is contraindicated~~
~~(ACR, 2015; AAFP, 2012; ACEP, 2014; NASS, 2013; Chou, 2007; Jarvik, 2015; Last, 2009)~~

- ~~With new or worsening objective neurologic deficits on exam~~
- ~~Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.~~
- ~~With progression or worsening of symptoms during the course of conservative treatment*.~~
- ~~With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a lumbar radiculopathy. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013)).~~

~~For evaluation of new onset of back pain when Lumbar Spine MRI is contraindicated~~
~~(ACR, 2015; AANSCNS, 2014; ACA, 2017; ACEP, 2014; Chou, 2007)~~

- ~~With new or worsening objective neurologic deficits on exam~~
- ~~Failure of conservative treatment*, for at least six (6) weeks within the last six (6) months.~~
- ~~With progression or worsening of symptoms during the course of conservative treatment*.~~

- ~~With an abnormal electromyography (EMG) or nerve conduction study if (if performed) indicating a lumbar radiculopathy. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013))~~

For evaluation of trauma or acute injury
(ACR, ~~2012~~**2018**; Chou, 2007**,** Koivikko, 2008)

- Presents with **any of the following neurological deficits:** radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes ~~[~~along a particular dermatome (nerve distribution)].
- With progression or worsening of symptoms during the course of conservative treatment*.
- **History of underlying spinal abnormalities (i.e. ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis (DISH))** ~~(Koivikko, 2008)~~

Pars defect (spondylolysis) or spondyloli~~i~~**sthesis**

- Pars defect (spondylolysis) or spondyl**oli**~~i~~sthesis in adults when Flexion/Extension x-rays show instability.
- **Clinically suspected Pars defect (spondylolysis)** ~~with spondylisthesis)~~ **which is not seen on plain films in pediatric population (<18 yr) (flexion extension instability not required) and imaging would change treatment (Cohen, 2005; Kobayashi, 2013; Rush, 2015)**~~-~~ **when MRI is contraindicated.**~~Pars defect (spondylolysis with spondylisthesis) on plain films in pediatric population (<18 yr) (flexion extension instability not required) when MRI is contraindicated.~~

NOTE: Initial imaging (x-ray, or planar bone scan without SPECT; Bone scan with SPECT is superior to MRI and CT in the detection of ~~of~~ pars intrarticularis pathology including spondylolysis) (Matesan, 2016).

For evaluation of known or new compression fractures with worsening back pain (ACR, 2018)

- With history of malignancy when MRI is contraindicated.
- With an associated new focal neurologic deficit
- Prior to a planned surgery/intervention or if the results of the MRI will change management.

For evaluation of known tumor, cancer, or evidence of metastasis with any of the following (Last, 2009) **(MRI is usually the preferred study, but CT may help characterize solitary indeterminate bone lesions)**~~.~~
(Kim, 2012).

- For staging of known tumor.
- For follow-up evaluation of patient undergoing active cancer treatment.
- Presents with new signs or symptoms (e.g., physical, laboratory, and/or imaging findings) of new tumor or change in tumor.
- With evidence of metastasis on bone scan or previous imaging study.

- **Initial imaging of new or increasing non-traumatic back pain or radiculopathy or back that pain occurs at night ~~,~~ and wakes the patient from sleep with known active cancer and a tumor that tends to metastasize to the spine (ACR, 2018; Ziu, 2019).**

For evaluation of suspected tumor when Lumbar Spine MRI is contraindicated or inappropriate
(ACR, 2015)
- Prior abnormal or indeterminate imaging that requires further clarification

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:
- ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.

For evaluation of known or suspected infection, abscess, or inflammatory disease when Lumbar Spine MRI is contraindicated
(ACR, 2015; Last, 2009; Lerner, 2018)
- **Infection:**
  - **As evidenced by signs and/or symptoms, laboratory (i.e. abnormal white blood cell count, ESR and/or CRP) or prior imaging findings (Bond, 2016)**
  - **Follow up imaging of infection**
    - **With worsening symptoms/laboratory values (i.e. white blood cell count, ESR/CRP) or radiographic findings (Berbari, 2015)**
- ~~As evidenced by signs/symptoms, laboratory or prior imaging findings.~~

For evaluation of spine abnormalities related to immune system suppression, e.g., HIV, chemotherapy, leukemia, or lymphoma and Lumbar Spine MRI is contraindicated
(ACR, 2015)
- As evidenced by signs/symptoms, laboratory, or prior imaging findings.

As part of initial post-operative / procedural evaluation ("CT best examination to assess for hardware complication, extent of fusion" (ACR, 2015; Rao, 2018) **and MRI for cord, nerve root compression, disc pathology, or post-op infection):**
- A follow-up study may be needed to help evaluate a patient's progress after treatment, procedure, intervention, or surgery in the last 6 months. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
- Changing neurologic status post-operatively.
- Surgical infection as evidenced by signs/symptoms, laboratory, or prior imaging findings.
- Residual or recurrent symptoms with any of the following neurological deficits: Lower extremity weakness, objective sensory loss, or abnormal reflexes (Rao, 2018).

Other indications for a Lumbar Spine CT

- For preoperative evaluation and Lumbar Spine MRI is contraindicated
- CT discogram.
- Suspicious sacral dimple (those that are deep, larger than 0.5 cm, located within the superior portion of the gluteal crease or above the gluteal crease, or associated with other cutaneous markers) (**Choi, 2018;** D'Alessandro, 2009~~; Choi, 2018~~) in patients < 6 months should have ultrasound) when **Lumbar Spine MRI is contraindicated**.
- Tethered cord or spinal dysraphism (known or suspected) based on preliminary imaging, neurological exam, and/or ~~high risk~~**high-risk** cutaneous stigmata (AANS **2019**; Duz, 2008; Milhorat, 2009~~; NIH~~) when **Lumbar Spine MRI is contraindicated.**
- For suspected Ankylosing Spondylitis/Spondyloarthropathies with non-diagnostic or indeterminate x-ray and rheumatology workup
- Known Arnold-Chiari syndrome and **Lumbar Spine MRI is contraindicated** (Milhorat, 2009; Strahle, 2015).
- Congenital abnormalities when **Lumbar Spine MRI is contraindicated** or for characterization of boney detail (Trenga, 2016)**:**
    - In the presence of neurologic deficit, progressive spinal deformity, or for preoperative planning (Trenga, 2016)
    - Back pain and vertebral anomalies (hemivertebrae, hypoplasia, agenesis, butterfly, segmentation defect, bars, or congenital wedging) in a child on preliminary imaging.
    - Scoliosis with any of the following:
        - Progressive spinal deformity;
        - Neurologic deficit;
        - Early onset;
        - Atypical curve (e.g., short segment, > ~~30'~~ **30 degree** kyphosis, left thoracic curve, associated organ anomalies);
        - Pre-operative planning; OR
        - When office notes clearly document how imaging will change management.
- CSF leak highly suspected and supported by patient history and/or physical exam findings (CT Myelogram)
- For pediatric population if MRI is contraindicated (ACR, 2016)
    - Red flags that prompt imaging should include the presence of constant pain, night pain, and radicular pain lasting for 4 weeks or more **and initial radiographs preformed (ACR, 2016)**~~.~~.
    - Back pain associated with suspected inflammation, infection, or malignancy

COMBINATION STUDIES WITH LUMBAR SPINE CT:

Cervical/Thoracic/Lumbar CTs:

- CT myelogram or discogram
- Any combination of these for scoliosis survey in infant/child when MRI is contraindicated (Strahle, 2015).
- Any combination of these for spinal survey in patient with metastasis.

- For evaluation of spinal abnormalities associated with Arnold-Chiari Malformation (C/T/L spine due to association with tethered cord and syringomyelia) (Milhorat, 2009; Strahle, 2015) and **Lumbar Spine MRI is contraindicated**.
- Tethered cord, or spinal dysraphism (known or suspected) based on preliminary imaging, neurological exam, and/or cutaneous stigmata (AANS **2019**; Duz, 2008; Milhorat, 2009; NIH), when anesthesia required for imaging and **MRI is contraindicated.**
- Drop metastasis from the brain or spine **when MRI contraindicated** (imaging also includes brain; CT spine imaging in this scenario is usually CT myelogram).
- **CSF leak highly suspected and supported by patient history and/or physical exam findings**

BACKGROUND:

Computed tomography is used for the evaluation, assessment of severity, and follow-up of diseases of the spine. Its use in the thoracic spine is limited, however, due to the lack of epidural fat in this part of the body. CT myelography improves the contrast severity of CT, but it is also invasive. CT may be used for conditions, e.g., degenerative changes, infection, and immune suppression, when magnetic resonance imaging (MRI) is contraindicated. It may also be used in the evaluation of tumors, cancer, or metastasis in the thoracic spine and it may be used for preoperative and post-surgical evaluations. CT obtains images from different angles and uses computer processing to show a cross-section of body tissues and organs. CT is fast and is often performed in acute settings. It provides good visualization of cortical bone. ~~Computed tomographic scans provide bone detail and define the bony anatomy in multiple planes. It demonstrates the lumbar subarachnoid space and provides moderately good visualization of the vertebral canal. Three-dimensional reconstructions using CT help to demonstrate the anatomy of the vertebral canal.~~

OVERVIEW:

Ankylosing Spondylitis/Spondyloarthropathies is a cause of back or sacroiliac pain of insidious onset (usually > 3 month), associated with morning stiffness not relieved with rest (usually age at onset <40). It is associated with any of the following (Akgul, 2011; Bennett, 2010; Ostergaard, 2012; Seiper, 2014):

- Sedimentation rate and/or C-reactive protein (not an essential criteria).
- HLA B27 (not an essential criteria).
- Non-diagnostic or indeterminate x-ray
- Personal or family history of sacroilitis, peripheral inflammatory arthritis, and/or inflammatory bowel disease.

***Conservative Therapy:** (spine) should include a multimodality approach consisting of a **combination of active and inactive components**. Inactive components, such as rest, ice, heat, modified activities, medical devices, acupuncture and/or stimulators, medications, injections (epidural, facet, bursal, and/or joint, not including trigger point), and diathermy can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise

program**, **regular Osteopathic Manipulative medicine treatments** ~~osteopathic manipulative medicine (OMT)~~ **or chiropractic care.** ~~and/or chiropractic care~~.

****Home Exercise Program - (HEP)/Therapy** – the following elements are required to meet guidelines for completion of conservative therapy (ACR, 2015; Last, 2009):

- Information provided on exercise prescription/plan; AND
- Follow up with member with documentation provided regarding lack of improvement (failed) after completion of HEP (after suitable 6-week period), or inability to complete HEP due to physical reason- i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute "inability to complete" HEP).
- Dates and duration of failed PT, physician supervised HEP, or chiropractic treatment should be documented in the original office notes or an addendum to the notes.

CT and Cutaneous Stigmata (Dias, 2015)

TABLE 1 Risk Stratification for Various Cutaneous Markers

High Risk	Intermediate Risk	Low Risk
Hypertrichosis	Capillary malformations (also referred to as NFS or salmon patch when pink and poorly defined, or PWS when darker red and well defined)	Coccygeal dimple
Infantile hemangioma		Light hair
Atretic meningocele		Isolated café au lait spots
DST		Mongolian spots
Subcutaneous lipoma		Hypo- and hypermelanotic macules or papules
Caudal appendage		Deviated or forked gluteal cleft
Segmental hemangiomas in association with LUMBAR syndrome		Nonmidline lesions

LUMBAR, lower body hemangioma and other cutaneous defects, urogenital abnormalities, ulcerations, myelopathy, bony defects, anorectal malformations, arterial anomalies, and renal anomalies.

CT and Fracture of the Lumbar Spine – CT scans of the lumbar spine generate high-resolution spinal images; this and the absence of superimposed structures allow accurate diagnosis of lumbar fractures.

CT and Radiculopathy –Lumbar radiculopathy is caused by compression of a nerve root and/or inflammation that has progressed enough to cause neurologic symptoms, e.g., numbness, tingling, and weakness in leg muscles. These are warning signs of a serious medical condition which needs medical attention. Multidetector CT may be performed to rule out or localize

lumbar disk herniation before surgical intervention, when MRI is contraindicated. Radiation dose should be kept as low as possible in young individuals undergoing CT of the lumbar spine.

CT and Infection of the spine - Infection of the spine is not easy to differentiate from other spinal disorders, e.g., degenerative disease, spinal neoplasms, and non-infective inflammatory lesions. Infections may affect different parts of the spine, e.g., vertebrae, intervertebral discs, and paraspinal tissues. Imaging is important to obtain early diagnose and treatment to avoid permanent neurology deficits. When MRI is contraindicated, CT may be used to evaluate infections of the spine.

CT and Degenerative Disease of the Lumbar Spine – Stenosis of the lumbar canal may result from degenerative changes of the discs, ligaments and facet joints surrounding the lumbar canal. Compression of the microvasculature of the bundle of nerve roots in the lumbosacral spine may lead to significant effects on the cauda equina. This is a surgical emergency and CT may be performed to help assess the problem when MRI is contraindicated or inappropriate. CT scans can provide visualization of the vertebral canal and may demonstrate encroachment of the canal by osteophytes, facets, pedicles, or hypertrophied lamina.

Infection, Abscess, or Inflammatory disease

- **Most common site is the lumbar spine (58%), followed by the thoracic spine (30%) and the cervical spine (11%) (Graeber, 2019)**
- **High risk populations (indwelling hardware, history of endocarditis, IVDA, recent procedures) with appropriate signs/symptoms**

CT and Low Back Pain – Low back pain by itself is a self-limited condition which does not warrant any imaging studies. One of the "red flags" signifying a more complicated status is focal neurologic deficit with progressive or disabling symptoms. When magnetic resonance imaging (MRI) is contraindicated, CT of the lumbar spine with or without contrast is indicated for low back pain accompanied by a "red flag" symptom. Myelography combined with post-myelography CT is accurate in diagnosing disc herniation and may be useful in surgical planning. CT may be indicated when MRI is contraindicated, and chronic back pain unresponsive to conservative treatment; and unsuccessful physical therapy/home exercise program.

Tethered spinal cord syndrome - a neurological disorder caused by tissue attachments that limit the movement of the spinal cord within the spinal column. Although this condition is rare, it can continue undiagnosed into adulthood. The primary cause is mylelomeningocele and lipomyelomeningocele; the following are other causes that vary in severity of symptoms and treatment.

- Dermal sinus tract (a rare congenital deformity)
- Diastematomyelia (split spinal cord)
- Lipoma
- Tumor

- Thickened/tight filum terminale
- History of spine trauma/surgery
- Arnold Chiari Malformation**Spina Bifida Occulta** (AANS, 2020)

Sacral Dimples - Simple midline dimples are the most commonly encountered dorsal cutaneous stigmata in neonates and indicate low risk for spinal dysraphism. Only atypical dimples are associated with a high risk for spinal dysraphism, particularly those that are large (>5 mm), high on the back (>2.5 cm from the anus), or appear in combination with other lesions (D' Alessandro, 2009). High-risk cutaneous stigmata in neonates include hemangiomas, upraised lesions (i.e., masses, tails, and hairy patches), and multiple cutaneous stigmata. **1 in 1,000 individuals can have an occult structural finding that leads to neurological deficits or disabilities as bowel or bladder dysfunction, back pain, leg weakness or scoliosis**

Spina Bifida Occulta (AANS, 2020)

- **Called the hidden spina bifida, as the spinal cord and the nerves are usually normal and there is no opening on the skin on the back.**
- **This subtype, occurs in about 12% of the population and the majority of people are not aware that they have spina bifida occulta, unless it is discovered on an x-ray performed for an unrelated reason.**
- **Approximately, 1 in 1,000 individuals can have an occult structural finding that leads to neurological deficits or disabilities as bowel or bladder dysfunction, back pain, leg weakness or scoliosis**

Back Pain with Cancer - **History** Radiographic (x-ray) examination should be performed in cases of back pain when a patient has a cancer history. This can make a diagnosis in many cases. This may occasionally allow for selection of bone scan in lieu of MRI in some cases. When radiographs do not answer the clinical question, then MRI may be appropriate after a consideration of conservative care.

Neoplasms causing VCF (vertebral compression fractures) include: primary bone neoplasms, such as hemangioma or giant cell tumors, and tumor-like conditions causing bony and cellular remodeling, such as aneurysmal bone cysts, or Paget's disease (osteitis deformans); infiltrative neoplasms including and not limited to multiple myeloma and lymphoma, and metastatic neoplasms (ACR, 2018).

Most common spine metastasis involving primary metastasis originate from the following tumors in descending order: breast (21%), lung (19%), prostate (7.5%), renal (5%), gastrointestinal (4.5%), and thyroid (2.5%). While all tumor can seed to the spine, the cancers mentioned above metastasize to the spinal column early in the disease process (Ziu, 2019).

CT MYELOGRAM

Myelography is the instillation of intrathecal contrast media under fluoroscopy. Patients are then imaged with CT to evaluate for spinal canal pathology. Although this technique has

diminished greatly due to the advent of MRI due to its non-invasiveness and superior soft-tissue contrast, myelography is still a useful technique for conventional indications, such as spinal stenosis, when MRI is contraindicated or nondiagnostic, brachial plexus injury in neonates, radiation therapy treatment planning, and cerebrospinal fluid (CSF) leak.

CAUDA EQUINA SYNDROME:

- Symptoms include severe back pain or sciatica along with one or more of the following:
    - Saddle anesthesia - loss of sensation restricted to the area of the buttocks, perineum and inner surfaces of the thighs (areas that would sit on a saddle).
    - Recent bladder/bowel dysfunction (as listed above)
    - Achilles reflex absent on both sides
    - Sexual dysfunction that can come on suddenly
    - Absent anal reflex and bulbocavernosus reflex
- This is a "Red Flag" situation and Lumbar Spine MRI is approvable.

POLICY HISTORY:
Review Date: June 2019
Review Summary:

- Added CT myelogram
- Added new or worsening objective neuro deficits for chronic and acute back pain
- Added last 6 months for allowable post op follow up period and removed EMG comment
- Added section on pars defect
- Added section on compression fractures
- In other indications removed myelogram since covered previously
- Added congenital anomalies
- Added sacral dimple and scoliosis
- Added red flags specifically for peds back pain and pain related to malignancy, infection, inflammation
- Added CSF leak indication
- For combination studies C/T/L added drop metastasis, tethered cord, Arnold Chiari

Review Date: May 2020
Review Summary:

- **For evaluation of neurologic deficits added new deficits**
- **Added ankylosing spondylitis for evaluation of trauma/acute injury**
- **Added Osteopathic Manipulative medicine to conservative care therapy**
- **Modified Initial imaging of new or increasing non-traumatic back pain or radiculopathy or back pain that occurs at night and wakes the patient from sleep with known active cancer and a tumor that tends to metastasize to the spine**
- **Modified Pars fracture to not seen on radiograph and imaging would change management**
- **Combined the acute and chronic back pain sections**
- **Added spina bifida occulta to background section**

REFERENCES:

Akgul, O, Ozgocmen S. Classification criteria for spondyloarthropathies. *World J Orthop*. December 18, 2011; 2(12):107-115. doi: 10.5312/wjo.v2.i12.07. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3302034/.

American Academy of Family Physicians (AAFP). Fifteen Things Physicians and Patients Should Question. Choosing Wisely®. http://www.choosingwisely.org/societies/american-academy-of-family-physicians/. Published April 4, 2012.

American Association of Neurological Surgeons and Congress of Neurological Surgeons (AANSCNS). Five Things Physicians and Patients Should Question. Choosing Wisely®. http://www.choosingwisely.org/clinician-lists/american-association-neurological-surgeons-imaging-for-nonspecific-acute-low-back-pain/. Published June 24, 2014.

American Chiropractic Association (ACA). Five Things Physicians and Patients Should Question. Choosing Wisely®. http://www.choosingwisely.org/societies/american-chiropractic-association/. Published August 15, 2017.

American College of Emergency Physicians (ACEP). Ten Things Physicians and Patients Should Question. Choosing Wisely®. http://www.choosingwisely.org/societies/american-college-of-emergency-physicians/. Published October 27, 2014.

American College of Radiology (ACR). ACR Appropriateness Criteria®. http://www.acr.org/Quality-Safety/Appropriateness-Criteria/Diagnostic. Published 2015.

American College of Radiology (ACR). ACR Appropriateness Criteria®. Back Pain – Child. https://acsearch.acr.org/docs/3099011/Narrative/. Published 2016.

Bennett AN, Marzo-Ortega H, Rehman A, et al. The evidence for whole-spine MRI in the assessment of axial spondyloarthropathy. *Rheumatology*. March 2010; 49(3):426-432. https://doi.org/10.1093/rheumatology/kep427. https://academic.oup.com/rheumatology/article/49/3/426/1787410.

Berbari EF, Kanj SS, Kowalski TJ, et al. 2015 Infectious Diseases Society of America (IDSA) Clinical Practice Guidelines for the Diagnosis and Treatment of Native Vertebral Osteomyelitis in Adults. *Clin Infect Dis.* 2015 Sep 15; 61(6):e26–e46.

Chou R, Qaseem A, Snow V, et al. Diagnosis and treatment of low back pain: A joint clinical practice guideline from the American College of Physicians and the American Pain Society. *Ann Intern Med*. October 2, 2007; 147(7):478-491. http://annals.org/article.aspx?volume=147&issue=7&page=478.

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.

D' Alessandro D. Does This Sacral Dimple Need to be Evaluated? PediatricEducation.org™. Iowa City, IA: July 20, 2009. https://pediatriceducation.org/2009/07/20/does-this-sacral-dimple-need-to-be-evaluated/. Retrieved March 29, 2018.

Davis PC, Wippold FJ, Brunberg JA, et al. ACR appropriateness criteria on low back pain. *J Am Coll Radiol*. 2008; 6:401-407. doi: 10.1016/j.jacr.2009.02.008.

Graeber A, Cecava ND. Vertebral Osteomyelitis. [Updated 2019 Jun 3]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan.

Grams AE, Gempt J, Förschler A. Comparison of spinal anatomy between 3-Tesla MRI and CT-myelography under healthy and pathological conditions. *Surg Radiol Anat*. 2010; -32(6):581–585.

Jarvik JG, Gold LS, Comstock BA, et al. Association of early imaging for back pain with clinical outcomes in older adults. *JAMA*. 2015; 313(11):1143-1153. doi: 10.1001/jama.2015.1871.

Kim YS, Han IH, Lee IS, et al. Imaging findings of solitary spinal bony lesions and the differential diagnosis of benign and malignant lesions. Thank you,

Vernida Clark
Sr. Account Support Coordinator
NIA Magellan. August 2012; 52(2):126-132. doi: 10.3340/jkns.2012.52.2.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3467370/. Retrieved March 29, 2018.

Kobayashi A, Kobayashi T, Kato K, et al. Diagnosis of radiographically occult lumbar spondylolysis in young athletes by magnetic resonance imaging. *Am J Sports Med.* 2013; 41(1):169-176.

Koivikko MP, Koskinen SK. MRI of cervical spine injuries complicating ankylosing spondylitis. Skeletal Radiol. 2008 Sep;37(9):813-9. doi:10.1007/s00256-008-0484-x. Epub 2008 Apr 18.

Last AR, Hulbert K. Chronic low back pain: Evaluation and management. *Am Fam Physician*. 2009; 79(12):1067-74.

Lerner S, Hartmann S, Barbagallo GMV, et al. Management of spinal infection: A review of the literature. *Acta Neurochir (Wien)*. 2018; 160(3): 487-496.

Matesan M, Behnia F, Bermo M, et al. SPECT/CT bone scintigraphy to evaluate low back pain in young athletes: common and uncommon etiologies. *J Orthop Surg Res*. 2016; 11:76.

Milhorat TH, Bolognese PA, Nishikawa M, et al. Association of Chiari malformation type I and tethered cord syndrome: preliminary results of sectioning filum terminale. *Surg Neurol*. July 2009; 72(1):20-35. http://europepmc.org/abstract/med/19559924.

Morita M, Miyauchi A, Okuda S, et al. Comparison between MRI and myelography in lumbar spinal canal stenosis for the decision of levels of decompression surgery. *J Spinal Disord Tech.* 2011; 24(1):31-36.

Naganawa T, Miyamoto K, Ogura H, et al. Comparison of magnetic resonance imaging and computed tomogram-myelography for evaluation of cross sections of cervical spinal morphology. *Spine*. 2011; 36(1):50–56.

National Institute of Neurological Disorder and Stroke (NINDS). Tethered Spinal Cord Syndrome Information Page. http://www.ninds.nih.gov/disorders/tethered_cord/tethered_cord.htm. Published 2011.

North American Spine Society (NASS). Five Things Physicians and Patients Should Question. Choosing Wisely®. http://www.choosingwisely.org/societies/north-american-spine-society/. Published October 9, 2013.

North American Spine Society (NASS). Evidence-based Clinical Guidelines for Multidisciplinary Spine Care. Diagnosis and Treatment of Lumbar Disc Herniation with Radiculopathy. 2012. https://www.spine.org/Portals/0/Assets/Downloads/ResearchClinicalCare/Guidelines/LumbarDiscHerniation.pdf

Ostergaard M, Lambert RG. Imaging in ankylosing spondylitis. *Ther Adv Musculoskelet Dis.* August 2012; 4(4):301-311. doi: 10.1177/1759720X11436240. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3403247/. Retrieved March 29, 2018.

Ozdoba C, Gralla J, Rieke A, et al. Myelography in the age of MRI: Why we do it, and how we do it. *Radiol Res Prac*. 2011; Article ID 329017.

Pomerantz SR. Myelography: modern technique and indications. *Handb Clin Neurol*. 2016; 135:193-208.

~~Naganawa T, Miyamoto K, Ogura H, et al. Comparison of magnetic resonance imaging and computed tomogram-myelography for evaluation of cross sections of cervical spinal morphology. *Spine*. 2011; 36(1):50–56.~~

Rush JK, Astur N, Scott S, et al. Use of magnetic resonance imaging in the evaluation of spondylolysis. *J Pediatr Orthop*. 2015 Apr-May; 35(3):271-5.

Sieper J, Rudwaleit M, Baraliakos X, et al. The assessment of SpondyloArthritis international Society (ASAS) handbook: a guide to assess spondyloarthritis. *Ann Rheum Dis*. June 2009; 68 Suppl 2:ii1-44. Retrieved March 29, 2018.

Strahle J, Smith BW, Martinez M, et al. The association between Chiari malformation Type I, spinal syrinx, and scoliosis. *J Neurosurg Pediatr*. June 2015; 15(6):607-611. Retrieved March 29, 2018.

Trenga AP, Singla A, Feger MA, et al. Patterns of congenital bony spinal deformity and associated neural anomalies on X-ray and magnetic resonance imaging. *J Child Orthop*. August 2016; 10(4):343-352. doi: 10.1007/s11832-016-0752-6. Retrieved March 29, 2018.

Willen J, Wessberg PJ, Danielsson B. Surgical results in hidden lumbar spinal stenosis detected by axial loaded computed tomography and magnetic resonance imaging: An outcome study. *Spine*. 2008; 33(4):E109-E115. doi: 10.1097/BRS.0b013e318163f9ab.

Ziu E, Viswanathan VK, Mesfin FB. Cancer, Spinal Metastasis. [Updated 2020 Mar 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK441950/.

Reviewed / Approved by M. Atif Khalid MD ~~ng VP Medical Director~~ M. Atif Khalid, M.D., Medical Director, Radiology