National Imaging Associates, Inc.*	
Clinical guidelines **THORACIC SPINE MRI**	**Original Date: September 1997**
CPT Codes: 72146, 72147, 72157, +0698T	**Last Revised Date: ~~May~~ April 2021**
Guideline Number: NIA_CG_042	**Implementation Date: January 2022**

INDICATIONS FOR THORACIC SPINE MRI
(Combination requests at end of the document)

**For evaluation of neurologic deficits*
(Acharya, 2019; ACR, 2013; NASS, 2010; ~~Acharya, 2019,~~ Stolper, 2017)**

- **With any of the following new neurological deficits documented on physical exam**
  - **Extremity muscular weakness**
  - **Pathologic (e.g., Babinski, Lhermitte's sign, Chaddock Sign) or abnormal reflexes (Teoli, 2021)**
  - **Absent/decreased sensory changes along a particular thoracic dermatome (nerve distribution): pin prick, touch, vibration, proprioception, or temperature**
  - **Upper or lower extremity increase muscle tone/spasticity**
  - **New onset bowel or bladder dysfunction (e.g., retention or incontinence)**
  - **Gait abnormalities (see ~~table below~~Table 1 for more details*)**
- **Suspected cord compression with any neurological deficits as listed above.**

For evaluation of back pain with any of the following
(Allegri, 2016; AANSCNS, 2014; Jarvik, 2015)

- With new or worsening objective **neurologic deficits (as listed above) *** 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 thoracic radiculopathy. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013))~~.~~
- **Isolated back pain in pediatric population (ACR, 2016) – conservative care not required if red flags present (see combination request below cervical and lumbar spine may also be indicated)**
  - **Red flags that prompt imaging should include the presence of: age 5 or younger, constant pain, pain lasting >4 weeks, abnormal neurologic examination, early morning stiffness and/or gelling; night pain that prevents or disrupts sleep;**

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

radicular pain; fever; weight loss; malaise; postural changes (e.g., kyphosis or scoliosis); and limp (or refusal to walk in a younger child <5yo) AND initial radiographs have been performed (Bernstein, 2007; Feldman, 2006).

- Back pain associated with suspected inflammation, infection, or malignancy

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)

- For preoperative evaluation/planning.
- Prior to spinal cord stimulator to exclude canal stenosis if no prior MRI imaging of the thoracic spine has been done recently (Carayannopoulos, 2019).
- CSF leak highly suspected and supported by patient history and/or physical exam findings (leak (known or suspected spontaneous (idiopathic) intracranial hypotension (SIH), post lumbar puncture headache, post spinal surgery headache, orthostatic headache, rhinorrhea or otorrhea, or cerebrospinal-venous fistula))
- 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 (routine surveillance post-op not indicated without symptoms)
- Changing neurologic status post-operatively.
- Surgical infection as evidenced by signs/symptoms, laboratory, or prior imaging findings.
- Residual or new neurological deficits or symptoms (Rao, 2018)- see neurological deficit section above*
- When combo requests are submitted (i.e., MRI and CT of the spine), the office notes should clearly document the need for both studies to be done simultaneously, i.e., the need for both soft tissue and bony anatomy is required (Fisher, 2013).
    - Combination requests where both thoracic spine CT and MRI thoracic spine are both approvable (not an all-inclusive list):
        - OPLL (Ossification of posterior longitudinal ligament)-
            - Most common in cervical spine (rare but more severe in thoracic spine) (Choi, 2011)
        - Pathologic or complex fractures
        - Malignant process of spine with both bony and soft tissue involvement
        - Clearly documented indication for bony and soft tissue abnormality where assessment will change management for the patient.

~~For evaluation of neurologic deficits~~

- ~~With any of the following new neurological deficits: extremity muscular weakness (Acharya, 2019); pathologic (e.g., Babinski) or abnormal reflexes; or abnormal sensory changes along a particular dermatome (nerve distribution) as documented on physical exam; evidence of Cauda Equina Syndrome; bowel or bladder dysfunction; spasticity, sensory or motor level (Stolper, 2017).~~

For evaluation of suspected myelopathy

(ACR, 2015; Behrbalk, 2013; Davies, 2018; Sarbu, 2019; Vilaca, 2016~~, Sarbu 2010~~)

- **Does NOT require conservative care**
- **Progressive symptoms including hand clumsiness, worsening handwriting, difficulty with grasping and holding objects, diffuse numbness in the hands, pins and needles sensation, increasing difficulty with balance and ambulation**
- **Any of the neurological deficits* as noted above~~.~~**

~~(ACR, 2015; Behrbalk, 2013; Hou, 2016)~~

- ~~Does not require conservative care~~
- ~~Concurrent cervical/thoracic imaging not recommended~~
- ~~Progressive symptoms including hand clumsiness, worsening handwriting, difficulty with~~
- ~~With any of the following new neurological deficits: extremity muscular weakness; pathologic (e.g. Babinski, Hoffman's) or abnormal reflexes; or abnormal sensory changes along a particular dermatome (nerve distribution) as documented on physical exam; bowel or bladder dysfunction; spasticity, sensory, or motor level.~~

~~**For evaluation of known or suspected multiple sclerosis (MS)**~~

- ~~Suspected MS with new or changing symptoms consistent with thoracic spinal cord disease (i.e., transverse myelitis, progressive myelopathy)~~
- ~~Follow up of known Multiple Sclerosis with known thoracic involvement (CMSC, 2018)~~
- ~~Follow up to the initiation or change in medication for patient with known Multiple Sclerosis with thoracic involvement (CMSC, 2018)~~
- ~~Cervical and/or Thoracic MRI for evaluation of suspected multiple sclerosis (MS) when Brain MRI does not fulfill diagnostic criteria (Filippi, 2016)~~
- ~~Cervical and/or Thoracic MRI for evaluation of neuromyelitis optica spectrum disorders (recurrent or bilateral optic neuritis; recurrent transverse myelitis) (Wingerchuk, 2015)~~

For evaluation of known or suspected multiple sclerosis (MS)

(ACR, 2015; CMSC, 2018; Filippi, 2016; Kaunzner, 2017~~, CMSC, 2018~~)

- **Suspected or known MS with new or changing symptoms suggesting underlying thoracic spinal cord disease (i.e., transverse myelitis, progressive myelopathy)**
- **Suspected or known pediatric demyelinating diseases (MS/ADEM)**
- **Combination studies for MS**
    - **Cervical and/or Thoracic MRI for evaluation of suspected multiple sclerosis (MS) when Brain MRI does not fulfill diagnostic criteria (Filippi, 2016)~~.~~**
    - **Cervical and/or Thoracic MRI with suspected transverse myelitis~~ ~~~~with appropriate clinical symptoms (e.g., bilateral weakness, sensory disturbance, and autonomic dysfunction which typically evolve over hours or days)**
    - **Brain MRI with Cervical and/or Thoracic MRI for evaluation of neuromyelitis optica spectrum disorders (recurrent or bilateral optic neuritis; recurrent transverse myelitis) (Wingerchuk, 2015)**
    - **Known MS, entire CNS axis (Brain, and/or Cervical and/or Thoracic spine) is approvable prior to the initiation or change of disease modification treatments and assess disease burden (to establish a new baseline)**

- Follow-up scans, including brain and spine imaging, if patients have known spine disease:
  - 6-12 months after starting/changing treatment
  - Every 1-2 years while on disease-modifying therapy to assess for subclinical disease activity, less frequently when stable for 2-3 years

For evaluation of trauma or acute injury (ACR, 2018)

- Presents with any of the following neurological deficits~~: muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution)~~* as above~~.~~
- 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), both MRI and CT are approvable . (ACR, 2021; ~~Taljanovic ,~~Koivikko, 2008; Taljanovic, 2009~~,~~) ~~ACR)~~
- ~~History of underlying spinal abnormalities (i.e., ankylosing spondylitis) (Koivikko, 2008)~~When the patient is clinically unevaluable or there are preliminary imaging findings (x~~X~~-ray or CT) needing further evaluation~~.~~

("MRI and CT provide complementary information. When indicated i~~I~~t is appropriate to perform both examinations") (ACR, 2018).

~~**Ossification Posterior Longitudinal Ligament (OPLL)** (Choi, 2011)~~

- ~~CT to evaluate the calcification and MR for evaluation of cord.~~
  - ~~Both CT and MRI would be approvable if surgery is planned as signal changes in the cord would suggest a poorer prognosis after surgery.~~

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

- With history of malignancy~~y~~
  - To aid in differentiation of benign osteopeorotic fractures from metastatic disease
    - A follow~~-~~up MRI in 6-8 weeks after initial MRI when initial imaging cannot decipher (indeterminate) benign osteopeorotic fracture from metastatic disease (Kumar, 2016)
- With an associated new focal neurologic deficit* as above
- Prior to a planned surgery/intervention or if the results of the MRI will change management~~.~~

- ~~To aid in differentiation of benign osteoperotic fractures from metastatic disease~~
- ~~A follow up MRI in 6-8 weeks after initial MRI when initial imaging cannot decipher benign osteoperotic fracture from metastatic disease (Kumar, 2016)~~

For evaluation of tumor, cancer, or metastasis with any of the following (MRI is usually the preferred study, but CT may be needed to further characterize solitary indeterminate lesions seen on MRI)
(~~ACR, 2018;~~Kim, 2012; McDonald, 2019; Roberts, 2010)

Primary tumor~~:~~

- Initial staging or re-staging of a known primary spinal tumor~~.~~
- Known primary tumor with new signs or symptoms (e.g., new or increasing nontraumatic pain, physical, laboratory, and/or imaging findings)
- With an associated new focal neurologic deficit~~*~~ as above (Alexandru, 2012)

Metastatic tumor~~:~~

- With evidence of metastasis on bone scan needing further clarification OR inconclusive findings on a prior imaging exam
- Known malignancy with new signs or symptoms (e.g., new or increasing nontraumatic pain, physical, laboratory, and/or imaging findings) in a tumor that tends to metastasize to the spine
- With an associated new focal neurologic deficit (Alexandru, 2012)
- 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 (McDonald,2019~~ACR, 2018~~; Ziu, 2019)~~.~~

For evaluation of inconclusive finding on prior imaging that requires further clarification

- One follow-up exam to ensure no suspicious change has occurred in prior imaging finding. No further surveillance unless specified as highly suspicious or change was found on last follow-up exam (ACR, 2018)

~~For evaluation of known tumor, cancer, or evidence of metastasis with any of the following (MRI is usually the preferred study, but CT may help characterize solitary indeterminate 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.~~
- ~~New or increasing non-traumatic thoracic 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~~

~~(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
(ACR, 2015; 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)
    -
- **Spondyloarthropathies**
  - **Ankylosing Spondylitis/Spondyloarthropathies with non-diagnostic or indeterminate x-ray and appropriate rheumatology workup**

For evaluation of spine abnormalities related to immune system suppression, e.g., HIV, chemotherapy, leukemia, or lymphoma
(ACR, 2015)

- As evidenced by signs/symptoms, laboratory, or prior imaging findings.

Other Indications for a Thoracic Spine MRI
(Note- See combination requests, below, for initial advanced imaging assessment and pre-operatively)~~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 Thoracic Spine MRI**~~

- ~~For preoperative evaluation (Cohen, 2012)~~
- ~~Prior to spinal cord stimulator to exclude canal stenosis if no prior MRI imaging of the thoracic spine has been done recently (Carayannopoulos, 2019).~~
- ~~Suspected cord compression with any of the following neurological deficits: extremity weakness; sensory deficits, abnormal gait; abnormal reflexes; spinal level; bowel or bladder incontinence.~~
- **Tethered cord, or spinal dysraphism (known or suspected) based on preliminary imaging, neurological exam, and/or high-risk cutaneous stigmata (AANS, 2019; Duz, 2008; Milhorat, 2009).**
- **Known Arnold-Chiari syndrome (For initial imaging see combination below).**

- Known Chiari I malformation without syrinx or hydrocephalus, follow-up imaging after initial diagnosis with new or changing signs/symptoms or exam findings consistent with spinal cord pathology (Hitson, 2015)
- Known Chiari II (Arnold-Chiari syndrome), III, or IV malformation~~), III, or IV malformation.~~

- Syrinx or syringomyelia (known or suspected)~~:~~
  - With neurologic findings and/or predisposing conditions (e.g., Chiari malformation, prior trauma, neoplasm, arachnoiditis, severe spondylosis (Timpone, 2015))~~,~~
  - To further characterize a suspicious abnormality seen on prior imaging~~.~~
  - Known syrinx with new/worsening symptoms~~.~~
- Toe walking in a child when associated with upper motor neuron signs, including hyperreflexia, spasticity; or orthopedic deformity with concern for spinal cord pathology (e.g., pes cavus, clawed toes, leg or foot length deformity (excluding tight heel cords))
- ~~Tethered cord, or spinal dysraphism (known or suspected) based on preliminary imaging, neurological exam, and/or high-risk cutaneous stigmata (AANS, 2019; Milhorat, 2009).~~
- ~~Ankylosing Spondylitis/Spondyloarthropathies with non-diagnostic or indeterminate x-ray and rheumatology workup~~
- ~~Known Arnold-Chiari syndrome (Milhorat, 2009; Strahle, 2015).~~
  - ~~Chiari I malformation without syrinx or hydrocephalus, follow-up imaging after initial diagnosis for new or changing signs/symptoms or exam findings (Hitson, 2015)~~
- ~~Congenital abnormalities (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' kyphosis, left thoracic curve, associated organ anomalies);~~
    - ~~Pre-operative planning; OR~~
    - ~~When office notes clearly document how imaging will change management~~
- ~~Syrinx or syringomyelia (known or suspected) (Magge, 2011):~~
  - ~~With neurologic findings and/or predisposing conditions (e.g. Chiari malformation, prior trauma, neoplasm, arachnoiditis, severe spondylosis (Timpone, 2015)),~~
  - ~~To further characterize a suspicious abnormality seen on prior imaging.~~
  - ~~Known syrinx with worsening symptoms.~~
- ~~For pediatric population (ACR, 2016)~~
  - ~~Red flags that prompt imaging should include one or more of the following: 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 THORACIC SPINE MRI

Indications for combination studies: (ACR, 2017, 2019) - For approved indications as noted below and being performed in a child under 8 years of age who will need anesthesia for the procedure

Any combination of Cervical and/or Thoracic and/or Lumbar MRIs~~:~~

- **Any combination of these studies for:**
  - **Scoliosis survey in infant/child with congenital scoliosis or juvenile idiopathic scoliosis under the age of 10 (ACR, 2018; SRS, 2019; Strahle, 2015)~~.~~**
  - **In the presence of neurological 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 (Ozturk, 2010):**
    - **Progressive spinal deformity;**
    - **Neurologic deficit;**
    - **Early onset;**
    - **Atypical curve (e.g., short segment, >30' kyphosis, left thoracic curve, associated organ anomalies);**
    - **Pre-operative planning; OR**
    - **When office notes clearly document how imaging will change management**
- **Arnold~~-~~Chiari I (Radic, 2018; Strahle, 2011)**
  - **For evaluation of spinal abnormalities associated with initial diagnosis of Arnold-Chiari Malformation. (C/T/L spine due to association with tethered cord and syringomyelia), and initial imaging has not been completed (Milhorat, 2009; Strahle, 2015)~~.~~**
- **Arnold~~-~~Chiari II-IV**
  - **For initial evaluation and follow~~-~~up as appropriate**
- **Tethered cord, or spinal dysraphism (known or suspected) based on preliminary imaging, neurological exam, and/or high-risk cutaneous stigmata (AANS, 2019; Duz, 2008; Milhorat, 2009), when anesthesia required for imaging (Hertzler, 2010)~~.~~**
- **Toe walking in a child when associated with upper motor neuron signs including hyperreflexia, spasticity; or orthopedic deformity with concern for spinal cord pathology (e.g., pes cavus, clawed toes, leg or foot length deformity (excluding tight heel cords))**
- **Back pain in a child with any of the following red flags (conservative care not required when red flags present):**
  - **Red flags that prompt imaging should include the presence of: age 5 or younger, constant pain, pain lasting >4 weeks, abnormal neurologic examination, early morning stiffness and/or gelling; night pain that prevents or disrupts sleep;**

radicular pain; fever; weight loss; malaise; postural changes (e.g., kyphosis or scoliosis); and limp (or refusal to walk in a younger child <5yo), AND initial radiographs have been performed (Bernstein, 2007; Feldman, 2006)

- Drop metastasis from brain or spine (imaging also includes brain).
  - Suspected Leptomeningeal carcinomatosis (LC) (Shah, 2011)
  - Any combination of these for spinal survey in patient with metastases.
  - Tumor evaluation and monitoring in neurocutaneous syndromes - See Background
  - CSF leak highly suspected and supported by patient history and/or physical exam findings (leak (known or suspected spontaneous (idiopathic) intracranial hypotension (SIH), post lumbar puncture headache, post spinal surgery headache, orthostatic headache, rhinorrhea or otorrhea, or cerebrospinal-venous fistula))

~~Cervical/Thoracic/Lumbar MRIs~~

- ~~Any combination of these for scoliosis survey in infant/child with congenital scoliosis or under the age of 10 (ACR, 2018; Strahle, 2015).~~
- ~~Any combination of these for spinal survey in patient with metastases.~~
- ~~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).~~
- ~~Suspected Leptomeningeal carcinomatosis (LC) (Shah, 2011)~~
- ~~Tethered cord, or spinal dysraphism (known or suspected) based on preliminary imaging, neurological exam, and/or cutaneous stigmata (AANS, 2019; Milhorat, 2009), when anesthesia required for imaging~~

~~Drop metastasis from brain or spine (imaging also includes brain).~~
~~Tumor evaluation and monitoring in neurocutaneous syndromes - See Background~~
~~CSF leak highly suspected and supported by patient history and/or physical exam findings.~~

~~Cervical and Thoracic Combination MRI~~

- ~~Transverse Myelitis- with appropriate clinical symptoms (i.e. bilateral weakness, sensory disturbance, and autonomic dysfunction which typically evolve over hours or days (Goh, 2011); elevated protein on cerebrospinal fluid (CSF) analysis)~~

BACKGROUND

Magnetic resonance imaging (MRI) produces high quality multiplanar images of organs and structures within the body without using ionizing radiation. It is used for evaluation, assessment of severity, and follow-up of diseases of the spine and is the preferred modality for imaging intervertebral disc degeneration. High contrast resolution (soft tissue contrast) and multiplanar imaging (sagittal as well as axial planes) are helpful in the evaluation of possible disc herniation and detecting nerve root compression. MRI is one of the most useful techniques to evaluate spine infection and is also used to evaluate tumors, cancer, and immune system suppression.

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; Sieeiper, 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~~ **physician** supervised home exercise program**, and/or osteopathic manipulative medicine (OMT) or chiropractic care **when considered safe and appropriate**.

****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.

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

Table 1: Gait and spine imaging‡

Gait	Characteristic	Work up/Imaging
Hemiparetic	Spastic unilateral, circumduction	Brain and/or, Cervical spine imaging based on associated symptoms

Diplegic	Spastic bilateral, circumduction	Brain, Cervical and Thoracic Spine imaging
Myelopathic	Wide based, stiff, unsteady	Cervical and/or Thoracic spine MRI based on associated symptoms
Ataxic	Broad based, clumsy, staggering, lack of coordination, usually also with limb ataxia	Brain imaging
Apraxic	Magnetic, shuffling, difficulty initiating	Brain imaging
Parkinsonian	Stooped, small steps, rigid, turning en bloc, decreased arm swing	Brain Imaging
Choreiform	Irregular, jerky, involuntary movements	Medication review, consider brain imaging as per movement disorder Brain MR guidelines
Sensory ataxic	Cautious, stomping, worsening without visual input (ie + Romberg)	EMG, blood work, consider spinal (cervical or thoracic cord imaging) imaging based on EMG
Neurogenic	Steppage, dragging of toes	EMG→ foot drop Lumbar spine MRI Pelvis MR appropriate evidence of plexopathy
Vestibular	Insecure, veer to one side, worse when eyes closed, vertigo	Consider Brain/IAC MRI as per GL

(‡References: Chhetri, 2014; Clinch, 2021; Gait, 2021; Haynes, 2018; Marshall, 2012; Pirker, 2017)

~~Gait and spine imaging:~~

~~Gait~~	~~Characteristic~~	~~Work up/Imaging~~
~~Hemiparetic~~	~~Spastic unilateral, circumduction~~	~~Brain and/or, Cervical spine imaging based on associated symptoms~~
~~Diplegic~~	~~Spastic bilateral, circumduction~~	~~Brain, Cervical and Thoracic Spine imaging~~
~~Myelopathic~~	~~Wide based, stiff, unsteady~~	~~Cervical and/or Thoracic spine MRI based on associated symptoms~~
~~Ataxic~~	~~Broad based, clumsy, staggering, lack of coordination, usually also with limb ataxia~~	~~Brain imaging~~
~~Apraxic~~	~~Magnetic, shuffling, difficulty initiating~~	~~Brain imaging~~
~~Parkinsonian~~	~~Stooped, small steps, rigid, turning en bloc, decreased arm swing~~	~~Brain Imaging~~
~~Choreiform~~	~~Irregular, jerky, involuntary movements~~	~~Medication review, consider brain imaging as per movement disorder Brain MR guidelines~~
~~Sensory ataxic~~	~~Cautious, stomping, worsening without visual input (ie + Romberg)~~	~~EMG, blood work, consider spinal (cervical or thoracic cord imaging) imaging based on EMG~~
~~Neurogenic~~	~~Steppage, dragging of toes~~	~~EMG→ foot drop Lumbar spine MRI Pelvis MR appropriate evidence of plexopathy~~
~~Vestibular~~	~~Insecure, veer to one side, worse when eyes closed, vertigo~~	~~Consider Brain/IAC MRI as per GL~~

Table 2: MRI and Cutaneous Stigmata (Dias, 2015)

Risk Stratification for Various Cutaneous Markers		
High Risk	Intermediate Risk	Low Risk
• Hypertrichosis • Infantile hemangioma • Artretic meningocele • DST • Subcutaneous lipoma • Caudal appendage • Segmental hemangiomas in	• 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 • Light hair • Isolated café au lait spots • Mongolian spots • Hypo- and hypermelanotic macules or papules • Deviated or forked gluteal cleft • Nonmidline lesions

association with LUMBAR‡ syndrome		

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

~~MRI 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.

Myelopathy: Symptom severity varies, and a high index of suspicion is essential for making the proper diagnosis in early cases. Symptoms of pain and radiculopathy may not be present. The natural history of myelopathy is characterized by neurological deterioration. The most frequently encountered symptom is gait abnormality (86%) followed by increased muscular reflexes (79.1%), pathological reflexes (65.1%), paresthesia of upper limb (69.8%), and pain (67.4%) (Vitzthum, 2007).

Ossification Posterior Longitudinal Ligament (OPLL) (Choi, 2011) - Most common in cervical spine (rare but more severe in thoracic spine)

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 my~~l~~elomeningocele and lipomyelomeningocele; the following are other associations 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

Magnetic resonance imaging (MRI) can display the low level of the spinal cord and a thickened filum terminale, the thread-like extension of the spinal cord in the lower back. Treatment depends upon the underlying cause of the tethering. If the only abnormality is a thickened, shortened filum, then limited surgical treatment may suffice.

MRI and Spinal Infections – Infection of the spine is not easy to differentiate from other spinal disorders, e.g., degenerative disease, spinal neoplasms, and noninfectious 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~~**in obtaining an early diagnosis** and treatment to avoid permanent neurologic deficits. MRI is the preferred imaging technique to evaluate infections of the spine. With its high contrast resolution and direct multiplanar imaging, it has the ability to detect and delineate infective lesions irrespective of their spinal location.

Back Pain with Cancer History - Radiographic (x-ray) examination should be performed in cases of back pain when a patient has a cancer history, but without known active cancer or a tumor that tends to metastasize to the spine. 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 tumors can seed to the spine, the cancers mentioned above metastasize to the spinal column early in the disease process (Ziu, 2019).

~~CAUDA EQUINA SYNDROME~~**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

Spinal MRI and Neuromyelitis optica spectrum disorders (NMOSD) - NMOSD are inflammatory disorders of the central nervous system characterized by severe, immune-mediated demyelination and axonal damage predominantly affecting the optic nerves and spinal cord, but NMOSD may also affect the brain and brainstem. NMOSD can be distinguished from multiple sclerosis and other inflammatory disorders by the presence of the aquaporin-4 (AQP4) antibody. Features of NMOSD include attacks of bilateral or sequential optic neuritis acute transverse myelitis and the area postrema syndrome (with intractable hiccups or nausea and vomiting). The evaluation of suspected NMOSD entails brain and spinal cord neuroimaging. In contrast to MS (in which spinal cord involvement tends to be incomplete and asymmetric), NMOSD have a longer extent of spinal cord demyelination generally involving three or more vertebral segments.

POLICY HISTORY~~:~~

Date	Summary
April 2021	• Added/modified ○ Modified section on neurological deficits ○ Back pain in a child added/modified red flags ○ Gait table in background ○ Post-surgical modified/clarified surgical criteria for combination exams ○ Removed myelopathy combination studies ○ Updated/added MS Criteria ▪ Combination section for initial imaging and follow up ▪ Added pediatric MS ○ Modified known tumor imaging into primary and metastatic disease ○ Added toe walking for pediatric patients ○ Modified Combination exam wording
May 2020	• Added ○ For evaluation of neurologic deficits when new deficits are present ○ Removed pars defect section ○ Added ankylosing spondylitis for evaluation of trauma/acute injury ○ Added follow up of osteoporotic fracture from metastatic disease ○ Added transverse myelitis ○ 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 ○ Added Imaging of Ossification of the Posterior Longitudinal Ligament (OPPL) ○ Added Osteopathic Manipulative medicine to conservative care therapy
June 2019	• Added: ○ new or worsening objective neuro deficits for chronic and acute back pain ○ CSF leak ○ last 6 months for allowable post op f/u period and removed EMG comment ○ red flags specifically for peds back pain and pain related to malignancy, infection, inflammation ○ new sections: pars defect; compression fractures; congenital abnormalities including section on scoliosis and vertebral anomalies in children w/back pain; ○ For combination studies cervical/thoracic/lumbar added drop metastasis, tumor evaluation for neurocutaneous syndromes, and abnormalities associated w/Arnold Chiari, as well as separate indication for tethered cord or spinal dysraphism ○ Myelopathy ○ Pre op for spinal cord stimulator ○ Evaluation of MS including NMO disorders and recurrent transverse myelitis ○ Back pain in cancer patients with known active cancer in tumors that tend to metastasize ○ Expanded on tethered cord in Other Indications for Imaging and added content on sacral dimple

~~**Review Date:** June 2019~~
~~**Review Summary:**~~
- ~~Added:~~
  - ~~new or worsening objective neuro deficits for chronic and acute back pain~~
  - ~~CSF leak~~
  - ~~last 6 months for allowable post op f/u period and removed EMG comment~~
  - ~~red flags specifically for peds back pain and pain related to malignancy, infection, inflammation~~
  - ~~new sections: pars defect; compression fractures; congenital abnormalities including section on scoliosis and vertebral anomalies in children w/back pain;~~

- For combination studies cervical/thoracic/lumbar added drop metastasis, tumor evaluation for neurocutaneous syndromes, and abnormalities associated w/Arnold Chiari, as well as separate indication for tethered cord or spinal dysraphism
- Myelopathy
- Pre-op for spinal cord stimulator
- Evaluation of MS including NMO disorders and recurrent transverse myelitis
- Back pain in cancer patients with known active cancer in tumors that tend to metastasize
- Expanded on tethered cord in Other Indications for Imaging and added content on sacral dimple

Review Date: May 2020

Review Summary:

- Added
  - For evaluation of neurologic deficits when new deficits are present
  - Removed pars defect section
  - Added ankylosing spondylitis for evaluation of trauma/acute injury
  - Added follow up of osteoporotic fracture from metastatic disease
  - Added transverse myelitis
  - 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
  - Added Imaging of Ossification of the Posterior Longitudinal Ligament (OPPL)
  - Added Osteopathic Manipulative medicine to conservative care therapy

April 2021

- Added/modified
  - Modified section on neurological deficits
  - Back pain in a child added/modified red flags
  - Gait table in background
  - Post-surgical modified/clarified surgical criteria for combination exams
  - Removed myelopathy combination studies
  - Updated/added MS Criteria
    - Combination section for initial imaging and follow up
    - Added pediatric MS
  - Modified known tumor imaging into primary and metastatic disease
  - Added toe walking for pediatric patients
  - Modified Combination exam wording

REFERENCES:

Acharya AB, Fowler JB. Chaddock Reflex. [Updated 2019 Dec 15]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan. https://www.ncbi.nlm.nih.gov/books/NBK519555/.

Akgul O, Ozgocmen S. Classification criteria for spondyloarthropathies. *World J Orthop.* Dec 18, 2011; 2(12):107-115. doi: 10.5312/wjo.v2.i12.07. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3302034/. Retrieved March 29, 2018.

Allegri M, Montella S, Salici F, et al. Mechanisms of low back pain: A guide for diagnosis and therapy v.2. *F100Res*. 2016; 5.

Alexandru D. Evaluation and management of vertebral compression fractures. *Perm J.* Published online October 30, 2012:46-51. doi:10.7812/TPP/12-037.

American Association of Neurological Surgeons (AANS). Tethered spinal cord syndrome. 2019.

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

American College of Radiology (ACR). ACR Appropriateness Criteria® - Back Pain–Child. 2016.

American College of Radiology (ACR). ACR Appropriateness Criteria®. Inflammatory Back Pain: Known or Suspected Axial Spondyloarthritis. https://acsearch.acr.org/docs/3094107/Narrative/. Revised 2021.

American College of Radiology (ACR). ACR Appropriateness Criteria® – Low Back Pain. https://acsearch.acr.org/list. Published 2015.

American College of Radiology (ACR). ACR Appropriateness Criteria® - Management of Vertebral Compression Fractures. 2018.

American College of Radiology (ACR). ACR Appropriateness Criteria® - Myelopathy. 2015.

Behrbalk E, Salame K, Regev GJ, et al. Delayed diagnosis of cervical spondylotic myelopathy by primary care physicians. *Neurosurg Focus*. July 2013; 35(1):1-6.

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. Retrieved May 12, 2018.

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.

Bernstein RM, Cozen H. Evaluation of back pain in children and adolescents. *Am Fam Physician*. 2007;76(11):1669-1676.

Bond A, Manian FA. Spinal epidural abscess: A review with special emphasis on earlier diagnosis. *Biomed Res Int*. 2016; 2016:1614328.

Carayannopoulos A, Han A, Telfeian AE, et al. Preoperative Surveillance Thoracic MRI for Thoracic Dorsal Column Stimulation: Case Series. *Interventional Pain Management Rep.* 2019; 3(1):1-7.

Chhetri SK, Gow D, Shaunak S, Varma A. Clinical assessment of the sensory ataxias; diagnostic algorithm with illustrative cases. *Pract Neurol*. 2014;14(4):242-251. doi:10.1136/practneurol-2013-000764.

Choi BW, Song KJ, Chang H. Ossification of the posterior longitudinal ligament: A review of literature. *Asian Spine J*. 2011; 5(4):267–276. doi:10.4184/asj.2011.5.4.267.

Choosing Wisely®. Lists. http://www.choosingwisely.org/clinician-lists/#keyword=spine&topic-area=Radiology&service=Imaging. Retrieved March 27, 2018.

Clinch J, Wood M, Driscoll S. Evaluation of gait disorders in children. BMJ Best Practice. Published February 23, 2021. Accessed July 14, 2021. https://bestpractice.bmj.com/topics/en-us/709.

Cohen SP, Gupta A, Strassels SA, et al. Effect of MRI on treatment results or decision making in patients with lumbosacral radiculopathy referred for epidural steroid injections: a multicenter, randomized controlled trial. *Arch Intern Med*. 2012 Jan 23; 172(2):134-42.

Consortium of Multiple Sclerosis Centers (CMSC). 2018 Revised guidelines of the consortium of MS centers MRI protocol for the diagnosis and follow-up of MS. 2018. **https://cdn.ymaws.com/www.mscare.org/resource/collection/9C5F19B9-3489-48B0-A54B-623A1ECEE07B/2018MRIGuidelines_booklet_with_final_changes_0522.pdf. Retrieved July 15, 2021.**

D' Alessandro. 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.

Davies BM, Mowforth OD, Smith EK, et al. Degenerative cervical myelopathy. *BMJ*. 2018; 360. doi: https://doi.org/10.1136/bmj.k186.

Dias M, Partington M. Congenital brain and spinal cord malformations and their associated cutaneous markers. *Pediatrics.* 2015; 136(4):e1105-19.

Duz B, Gocmen S, Secer HI, et al. Tethered cord syndrome in adulthood. *J Spinal Cord Med*. 2008; 31(3):272-278. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2565560/. Retrieved March 29, 2018.

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. doi:10.1097/01.bpo.0000214928.25809.f9.

Filippi M, Rocca MA, Ciccarelli O, et al. MRI criteria for the diagnosis of multiple sclerosis: MAGNIMS consensus guidelines. *Lancet Neurol*. March 2016; 15(3):292-303. doi: 10.1016/S1474-4422(15)00393-2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4760851/. Retrieved May 8, 2018.

Fisher BM, Cowles S, Matulich JR, Evanson BG, Vega D, Dissanaike S. Is magnetic resonance imaging in addition to a computed tomographic scan necessary to identify clinically significant cervical spine injuries in obtunded blunt trauma patients? *Am J Surg*. 2013;206(6):987-993; discussion 993-994. doi:10.1016/j.amjsurg.2013.08.021.

Gait abnormalities. Stanford Medicine 25. Published 2021. Accessed July 14, 2021. https://stanfordmedicine25.stanford.edu/the25/gait.html.

Goh C, Phal PM, Desmond PM. Neuroimaging in acute transverse myelitis. *Neuroimaging Clin N Am*. 2011 Nov; 21(4):951-73.

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

Haynes KB, Wimberly RL, VanPelt JM, Jo C-H, Riccio AI, Delgado MR. Toe walking: A neurological perspective after referral from pediatric orthopaedic surgeons. *Journal of Pediatric Orthopaedics*. 2018;38(3):152-156. doi:10.1097/BPO.0000000000001115.

Hertzler DA, DePowell JJ, Stevenson CB, Mangano FT. Tethered cord syndrome: A review of the literature from embryology to adult presentation. *Neurosurg Focus*. 2010;29(1):E1. doi:10.3171/2010.3.FOCUS1079.

Hitson WJ, Lane JR, Bauer DF, et al. A prospective natural history study of nonoperatively managed Chiari I malformation: Does follow-up MRI surveillance alter surgical decision making? *J Neurosurg Pediatr*. 2015 Aug; 16(2):159-66.

Hou X, Sun C, Liu X, et al. Clinical features of thoracic spinal stenosis-associated myelopathy: A retrospective analysis of 427 cases. *Clin Spine Surg*. 2016; 29(2):86–89.

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.

Kaunzner UW, Gauthier SA. MRI in the assessment and monitoring of multiple sclerosis: An update on best practice. *Ther Adv Neurol Disord*. 2017;10(6):247-261. doi:10.1177/1756285617708911.

Kim YS, Han IH, Lee IS, et al. Imaging findings of solitary spinal bony lesions and the differential diagnosis of benign and malignant lesions. *J Korean Neurosurg Soc.* 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.

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.

Kumar Y, Hayashi D. Role of magnetic resonance imaging in acute spinal trauma: A pictorial review. *BMC Musculoskelet Disord*. 2016; 17:310.

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. doi: 10.1007/s00701-018-3467-2.

Magge SN, Smyth MD, Governale LS, et al. Idiopathic syrinx in the pediatric population: A combined center experience. *J Neurosurg Pediatr*. 2011 Jan; 7(1):30-6.
McDonald MA, Kirsch CFE, Amin BY, et al. ACR Appropriateness Criteria® cervical neck pain or cervical radiculopathy. *J Am Coll Radiol*. 2019;16(5S):S57-S76. doi:10.1016/j.jacr.2019.02.023.

Marshall FJ. Approach to the elderly patient with gait disturbance. *Neurol Clin Pract*. 2012;2(2):103-111. doi:10.1212/CPJ.0b013e31825a7823.

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 1, 2009; 72(1):20-35. http://europepmc.org/abstract/med/19559924. Retrieved March 29, 2018.

North American Spine Society (NASS). Clinician Lists. Choosing Wisely®. http://www.choosingwisely.org/clinician-lists/nass-emg-nerve-conduction-studies-to-determine-cause-of-spine-pain/. Released October 9, 2013.

North American Spine Society (NASS). Evidence-based Clinical Guidlines for Multidisciplinary Spine Care. Diagnosis and Treatment of Cervical Radiculopathy from Degenerative Disorders. 2010 North American Spine Society. https://www.spine.org/Portals/0/Assets/Downloads/ResearchClinicalCare/Guidelines/CervicalRadiculo pathy.pdf

North American Spine Society (NASS). Five Things Physicians and Patients Should Question. Choosing Wisely®. http://www.choosingwisely.org/doctor-patient-lists/north-american-spine-society/. 2014.

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.

Ozturk C, Karadereler S, Ornek I, Enercan M, Ganiyusufoglu K, Hamzaoglu A. The role of routine magnetic resonance imaging in the preoperative evaluation of adolescent idiopathic scoliosis. *Int Orthop*. 2010;34(4):543-546. doi:10.1007/s00264-009-0817-y.

Papanastassious ID, Gerochristou M, Aghayev K, et al. Defining the indications, types and biomaterials of corpectomy cages in the thoracolumbar spine. *Expert Rev Med Devices*. 2013; 10(2):269-79. doi: 10.1586/erd.12.79.

Pirker W, Katzenschlager R. Gait disorders in adults and the elderly: A clinical guide. *Wien Klin Wochenschr*. 2017;129(3-4):81-95. doi:10.1007/s00508-016-1096-4.

Radic JAE, Cochrane DD. Choosing wisely canada: pediatric neurosurgery recommendations. *Paediatr Child Health*. 2018;23(6):383-387. doi:10.1093/pch/pxy012.

Rao D, Scuderi G, Scuderi C, Grewal R, et al. The use of imaging in management of patients with low back pain. *J Clin Imaging Sci*. 2018 Aug 24; 8:30.

Roberts CC, Daffner RH, Weissman BN, et al. ACR Appropriateness Criteria® on metastatic bone disease. *J Am Coll Radiol*. 2010;7(6):400-409. doi:10.1016/j.jacr.2010.02.015.

Sarbu N, Lolli V, Smirniotopoulos JG. Magnetic resonance imaging in myelopathy: a pictorial review. *Clin Imaging*. 2019;57:56-68. doi:10.1016/j.clinimag.2019.05.002.

Scoliosis Research Society (SRS). Conditions and treatments: Juvenile scoliosis. 2019.

Shah LM, Salzman KL. Imaging of spinal metastatic disease. *Int J Surg Oncol*. 2011; 2011:769753.

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.

Stolper K, Haug JC, Christensen CT, et al. Prevalence of thoracic spine lesions masquerading as cauda equina syndrome: Yield of a novel magnetic resonance imaging protocol. *Intern Emerg Med*. 2017 Dec; 12(8):1259-1264. doi: 10.1007/s11739-016-1565-9.

Strahle J, Muraszko KM, Kapurch J, Bapuraj JR, Garton HJL, Maher CO. Chiari malformation Type I and syrinx in children undergoing magnetic resonance imaging. *J Neurosurg Pediatr*. 2011;8(2):205-213. doi:10.3171/2011.5.PEDS1121.

Strahle J, Smith BW, Martinez M, et al. The association between Chiari malformation Type I, spinal syrinx, and scoliosis. *J Neurosurg Pediatr*. 2015; 15:607-611. http://thejns.org/doi/pdf/10.3171/2014.11.PEDS14135. Retrieved March 29, 2018.

Taljanovic MS, Hunter TB, Wisneski RJ, et al. Imaging characteristics of diffuse idiopathic skeletal hyperostosis with an emphasis on acute spinal fractures: Review. *AJR Am J Roentgenol*. 2009;193(3 Suppl):S10-19, Quiz S20-24. doi:10.2214/AJR.07.7102.

Teoli D, Rocha Cabrero F, Ghassemzadeh S. Lhermitte Sign. In: *StatPearls*. StatPearls Publishing; 2021. Accessed July 15, 2021. http://www.ncbi.nlm.nih.gov/books/NBK493237/

Timpone V, Patel SH. MRI of a syrinx: Is contrast material always necessary? Am J Roentgenol. 2015; 204:1082-1085. 10.2214/AJR.14.13310.

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. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4940247/. Retrieved March 29, 2018.

Vilaca C, Orsini M, Leite MAA, et al. Cervical spondylotic myelopathy: What the neurologist should know. *Neurol Int*. 2016 Nov 2; 8(4):6330. doi: 10.4081/ni.2016.6330.

Vitzthum H, Dalitz K. Analysis of five specific scores of cervical spondylogenic myelopathy. *Eur Spine J*. December 2007; 16(12):2096-2103. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2140133/.

Wingerchuk DM, Banwell B, Bennett JL, et al. International consensus diagnostic criteria for neuromyelitis optica spectrum disorders. *Neurology*. 2015 Jul 14; 85(2).

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 M. Atif Khalid, M.D., Medical Director, Radiology

Reviewed / Approved by NIA Clinical Guideline Committee

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. If applicable: All prior relevant imaging results and the reason that alternative imaging cannot be performed must be included in the documentation submitted.