Pediatric Spine MRI

- Spinal MRI may be indicated for pediatric patients with:
  - New onset neurological symptoms, such as bowel or bladder issues and/or extremity weakness,
  - New or rapidly progressive scoliosis,
  - Persistent back pain and/or signs of infection
- It is often necessary to image the entire spine in order to correctly determine the anatomic location of disease.

Figure 1. 8-year-old with tethered cord syndrome. Sagittal T1 (A) and T2 (B) weighted imaging of the lumbar spine displays a low lying conus along with syringohydromyelia (upper arrow in B) seen along the distal thoracic spine and upper lumbar spine. A T1 linear hyperintensity is seen along the cauda equina nerve roots extending from the region of the conus is consistent with a fatty filum (arrow in A). The conus terminates into a filum terminale cyst at the sacral level (lower arrow in B).

MRI is the modality of choice for the detailed assessment of the spine in pediatric patients due to the combination of its multiplanar capabilities, excellent soft tissue contrast and lack of ionizing radiation. Neonatal patients may have spine imaging with ultrasound for certain indications because the posterior vertebral structures are still cartilaginous until approximately six weeks of age. However, MRI may still be required for further evaluation, especially if there are neurological symptoms.

Occult Spinal Dysraphisms

Patients with congenital spinal anomalies may present with cutaneous manifestations (open neural tube defects, atypical "dimples", hairy patch, hemangiomas, pigmented skin patches or fatty lumps) or with tethered cord syndrome (TCS). Open spinal dysraphisms and closed spinal dysraphisms with associated mass or atypical "dimple" are typically diagnosed in the perinatal period with ultrasound and may even be diagnosed prenatally. Occult spinal dysraphisms more commonly present in the years of rapid vertical growth (5-12 years), but can present at any age.
TCS denotes a complex of neurologic and orthopedic deformities commonly involving the onset of problems with bowel and/or bladder control and lower extremity neurologic problems, which can include stiffness or weakness, pain and flattening or eversion of the feet. Scoliosis frequently accompanies this syndrome, but is rarely the solitary complaint.

Considering that the location of the conus is typically abnormally low, accurately assessing its position is of critical importance (Figure 1). Spinal malformations in these children can also range from a single subtle anomaly to multiple gross abnormalities. Given the spectrum of findings seen with these congenital anomalies of the spine, whole spine MRI imaging is necessary, at least for initial evaluation.

**Scoliosis**

Scoliosis is common, affecting approximately 2% of children. The large majority of these children have idiopathic scoliosis with no other structural defect. Plain radiography is the standard method for monitoring the curvature of the spine in these children and may be sufficient for preoperative planning and post-operative assessment.

However, scoliosis can be associated with a tumor, Chiari I malformation, syringohydromyelia, tethered cord anomaly and intradural or extradural cysts. In Chiari I the cerebellar tonsils protrude through the foramen magnum and may be asymptomatic and incidental, Chiari I malformations can also, although infrequently, lead to syringomyelia (Figure 2) and neurological deficits. While severe spinal malformations will often be diagnosed in neonates, milder causative malformations may go undetected for many years. The first indication of a secondary scoliosis may be new or rapidly progressive scoliosis, especially if the curvature is left-sided, or it the child presents with pain or neurological symptoms, such as loss of bowel or bladder control or leg weakness.

Because surgical intervention can reduce symptoms and prevent further deterioration, early identification can be beneficial. Therefore, MRI is recommended for these children.

**Pain**

Persistent back pain is rare in healthy children who have no recent history of trauma and should be taken seriously. It can be a manifestation of infectious (e.g. osteomyelitis), congenital (e.g. tethered cord syndrome), neoplastic (e.g. lymphoma) and traumatic (e.g. spondylolysis) causes. Often, symptoms are non-specific and may wax and wane. Physicians may conduct tests for common causes for back pain, such as renal ultrasound for kidney stones or spinal radiography. However, these may not reveal the cause of the pain and more information may be needed from MRI.

Adolescent athletes, such as those involved in gymnastics, skating, soccer, swimming, or diving, can experience low back pain associated with repetitive stress. This may be due to spondylolysis (Figure 3), which results from a defect of the pars interarticularis of the vertebral posterior elements. Radiography is the primary tool for the diagnosis of spondylolysis. However, if symptoms are suggestive of spondylolysis and radiographs are normal, further imaging is warranted. Traditionally, a radionuclide bone scan is used for this purpose. However, MRI has the advantages of no ionizing radiation and can detect edema that is associated with stress lesions in both the pars and the adjacent pedicles. In addition, MRI has the ability to diagnose other causes of pain.
Figure 3. MRI images of an adolescent with spondylolysis. Arrows in (A) axial and (B) sagittal T2 images show a pars interarticularis defect in a patient with back pain.

Pain can also be due to an undiagnosed tumor. The most common intramedullary spinal neoplasms in children are astrocytomas and ependymomas (Figure 4) that may present with pain, neurological deficits, and gait abnormalities. Indications of a spinal cord tumor may be seen on radiography as an expansion of the vertebral column but this condition is best diagnosed with MRI. There are several types of bony tumors of the spine, which can present with pain including aggressive hemangiomas aneurysmal bone cysts, chondroblastomas, osteoid osteomas and metastases (e.g. neuroblastoma and Ewing sarcoma). These tumors can be difficult to visualize with radiographs. Although CT imaging shows superior bony detail, MRI has advantages in superior soft tissue evaluation and the absence of ionizing radiation.

Symptomatic degenerative changes are rare in the pediatric population and when present may be related to genetic factors. For example, Scheuermann’s disease is associated with early disk degeneration, thoracic kyphosis and multiple intervertebral disc herniations. While disk narrowing can be seen with radiography, the degenerative changes are best visualized with MRI.

Spinal infections also present with symptoms of pain, generally accompanied with fever. Discitis is more common in young children, with a mean age of 2.8 years. Osteomyelitis is more typically found in older children with systemic illness. In both cases, radiography will not reveal any signs until three weeks after disease onset but can be visualized with MRI much earlier because of the increased sensitivity to inflammation.

Figure 4. 15-year-old with myxopapillary ependymoma of the conus. Fat saturated T1 weighted imaging of the lumbar spine with gadolinium reveals an approximately 1 cm intradural mass (black arrow) lying just inferior to the conus (white arrow). The mass is in close continuity with the cauda equina nerve roots.
**Procedure**

Children are typically at least six years old before they are able to remain still long enough for MRI scanning without sedation or anesthesia, although a few children are able to do so at a younger age. A child life specialist will explain to the child what to expect and employs a number of strategies to reduce anxiety. Mass General Imaging offers MRI compatible video goggles, which have been very successful in aiding the examination of younger patient’s without sedation.

If the child is to receive anesthesia, a pediatric anesthesiologist will administer a short-acting anesthetic agent. The patient may also require advanced airway management during the sedation, at the discretion of the anesthesiologist. Contrast is not routinely administered and is added depending on the specific clinical situation. Typical scenarios for the use of contrast include: infection and known malignancy (e.g. brain cancer to assess for drop metastases, lymphoma or neuroblastoma).

Pediatric MRI spine protocols are custom-tailored for each specific indication. This is in contrast to typical adult spine protocols, which are typically based on the anatomic segment of interest (cervical, thoracic or lumbar). Many of the protocols include at least limited whole spine imaging. Presentations that are concerning for TCS require accurate placement of the conus. Chiari I malformations are associated with syringohydromyelia which can vary in location from the cervical spine through the conus, which makes whole spine screening essential upon first diagnosis or with new symptoms. Alternatively, a new diagnosis of a syringohydromyelia necessitates not only complete spine imaging, but also consideration of brain imaging to exclude a Chiari I malformation. Contrast may also be considered for the evaluation of a new syringohydromyelia as occult neoplasms can present in this fashion.

**Scheduling**

If the child can tolerate MRI without sedation/anesthesia, the exam can be scheduled through ROE or by calling 617-724-4972(XRAY). A child life specialist is available to speak with families to provide some information about what the child will experience by calling 617-724-1153. Pediatric MRI is available on the main campus and at the imaging centers in Chelsea, Waltham, and Worcester.

If it is anticipated that sedation or anesthesia will be necessary for successful completion of the examination or procedure, the Pediatric Radiology division must receive a completed Procedural Sedation / Anesthesia Requisition form prior to scheduling, together with the child’s recent clinical history and physical examination. The form also requests information on other tests that will be done immediately before or after the requested examination(s) while still under anesthesia or sedation. This information, together with the physical and clinical history, will determine whether the patient will receive sedation or anesthesia. Examinations using sedation or anesthesia are only conducted on the main campus. Patient information on preparing a child for sedation/general anesthesia is available on the Pediatric imaging website.

**Further Information**

For more information about pediatric spine MRI, please contact Paul Caruso, MD, or Jason Johnson, MD, Neuroimaging, Department of Radiology, Mass General Hospital, at 617-726-8323.

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References


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