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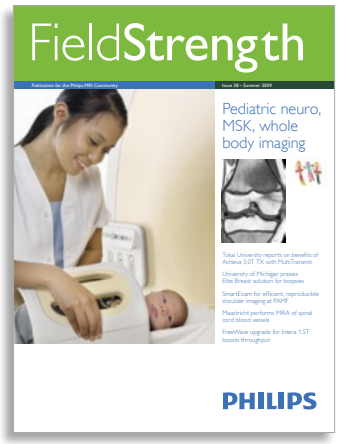

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PHILIPS

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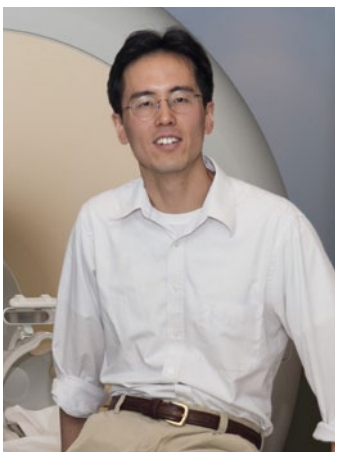

J. Herman Kan, MD.

In the growing field of pediatric musculoskeletal (MSK) imaging, image quality is vital, and special optimizations must be made for child-size anatomy. Pediatric MSK MR imaging can be divided roughly into two segments: sports medicine, predominantly standardized studies; and tumor/infection studies, usually tailored to a specific question and closely monitored by a radiologist to determine if the FOV is adequate to visualize the pathology and whether contrast is necessary.

J. Herman Kan, MD, is Assistant Professor of Radiology and Radiological Sciences at Monroe Carell Jr. Children's Hospital at Vanderbilt University (Nashville, Tennessee, USA). He strives to develop optimal pediatric MSK protocols on both the Achieva 3.0T X-series and the Achieva 1.5T.

Pediatric MSK imaging requires specially optimized protocols

Adult imaging protocols do not always translate well to children. "Pediatric MSK protocols must adapt coil selection, field of view (FOV), and in-plane resolution to children's smaller anatomy," says Dr. Kan. "This often adversely affects signal-to-noise ratio (SNR), and sequences must be refined to remain diagnostic, while getting the child on and off the table quickly, whether sedated or not."

"Knee MRI is probably the most common musculoskeletal MR study we do. If you use adult parameters on a 4-year-old knee, you'll be scanning from the mid tibia to the mid femur. You really need to just focus on the knee itself: about 2 cm above the physis of the distal femur to 1-2 cm below the physis of the proximal tibia. So, the FOV needs to be decreased from around 160 mm for an adult knee to about 80 mm for 4-year-old."

"When we just halve the FOV, then SNR issues arise. So, other modifications are also made, like SENSE factor, fat suppression, TE and TR, coil choice and more."

In addition, higher spatial resolution is required to delineate the smaller anatomy. "When we just halve the FOV and decrease pixel size, then SNR issues arise," Dr. Kan says. "So, other modifications are also made, like optimizing the SENSE factor, fat suppression, TE and TR, dealing with chemical shift effects, comparing different coils, comparing 1.5T and 3.0T."

"We have developed dedicated ExamCards for small, medium and large children, with optimized sequences for each body area."

'Bare bones protocol' is basis in pediatric sports medicine

"Pediatric and adolescent sports medicine is a rapidly growing field," Dr. Kan says. "It is important that radiologists are ready to address this population and create quality images that the orthopedist can trust prior to open and arthroscopic surgical interventions."

All pediatric musculoskeletal MRI exams need to include, at a minimum, certain key sequences. "You need to start out with this 'bare bones protocol'," explains Dr. Kan. "It should have fluid-sensitive sequences in three orientations for visualizing edema and cartilage – this may be any combination of fat-suppressed T2-weighted, fat-suppressed PD-weighted and STIR scans. It should include one or two anatomic T1- or PD-weighted sequences to evaluate cartilage, internal derangement and marrow, tailored for whichever body part is being imaged. And a susceptibility sequence, either 3D WATS or 2D FFE, is needed to evaluate for blood products or mineralization. When those basic sequences are established you can add to and deviate from them."

"We have developed dedicated ExamCards in small, medium and large versions, with optimized sequences for each body area that we are imaging. We prefer PD-weighted images without fat suppression for evaluating cartilage, and use a combination of PD-weighted and fluid sensitive sequences for visualizing ligaments. At 1.5T, we use STIR as our primary sequence to assess for edema as it provides very homogeneous fat suppression and we have carefully optimized the sequence. At 3.0T we prefer fat-saturated T2-weighted imaging as our workhorse, fluid-sensitive sequence for identifying soft tissue and marrow edema."

T2 FS coronal

Discoid lateral meniscus with bucket handle tear

8-year-old girl with intermittent knee popping. Sports medicine MRI protocol was performed using the SENSE 8-channel Knee coil on Achieva 3.0T. The lateral meniscus is globally enlarged, and the posterior horn of the lateral meniscus contains increased intrasubstance signal and is flipped anteriorly (arrows). Voxel size is 0.25 x 0.31 x 2.5 mm.

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Vanderbilt Children's Hospital

"We want to do the study as quickly as possible before the child starts moving and you get non-diagnostic images."

Fast scanning especially important in children

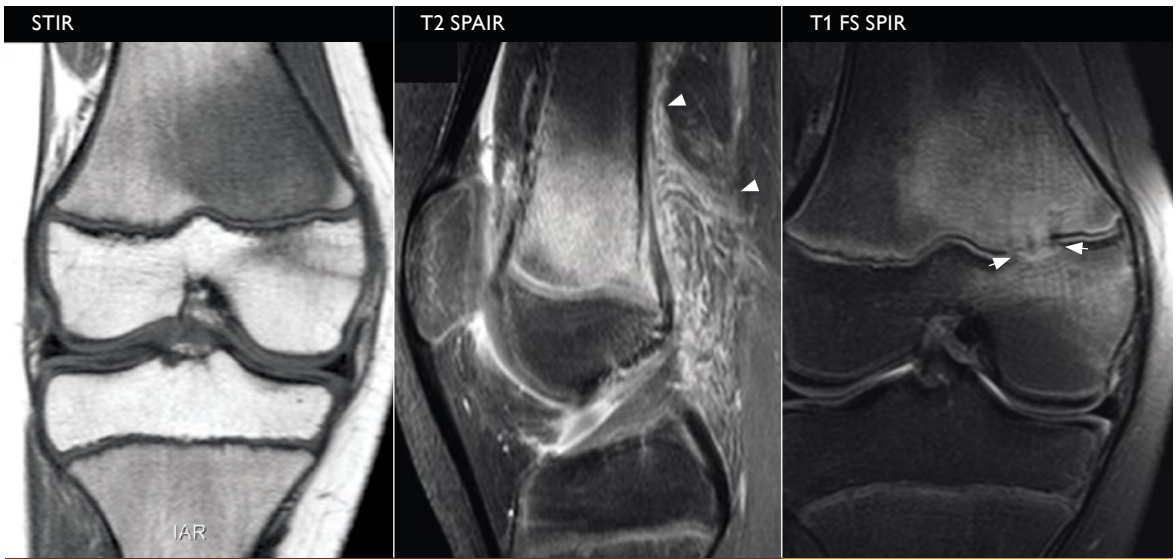
"When using the smaller FOV and optimizing image quality, scan time will increase," explains Dr. Kan. "However, pediatric patients generally have short attention spans, and can't always understand directions. So, we want to do the study as quickly as possible before the child starts moving and you get non-diagnostic images. Even if a child is sedated, we want to scan quickly to minimize the sedation time because sedation has its own inherent risks. Therefore, our protocols are tailored to balance the need for fast scanning and high resolution imaging."

Dr. Kan intensely optimized the knee exam because it is the most requested exam type. A regular sports medicine knee protocol of about 25 minutes includes sagittal T2-weighted fat-suppressed, PD-weighted and WATS; axial and coronal fat- suppressed PD-weighted; and an optional coronal T1-weighted scan for pre-school children.

"When needed, for instance to avoid sedation, we do a so-called 'fast knee' scan in only 7 to 10 minutes. The resolution will be decreased somewhat, and the study is not necessarily optimized for the size of the child. However, these studies often provide valuable diagnostic information, although less aesthetically pleasing, and we avoid the need for sedation."

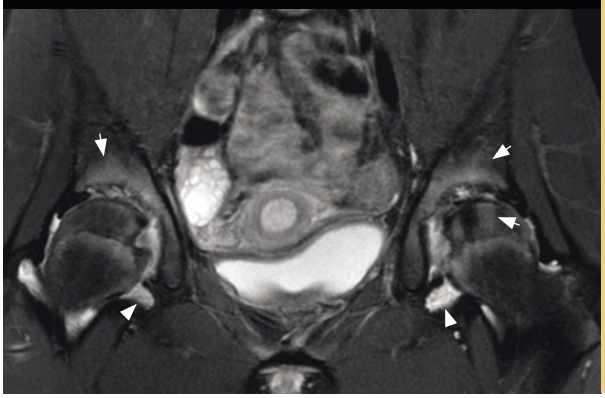
MSK oncology protocols help determine lesion extent

Dr. Kan has a special protocol for imaging skip lesions, separate lesions within the same bone, that may occur in patients with osteosarcoma and Ewing's sarcoma. "These skip lesions are important to find," says Dr. Kan, "because if these are present, there's a higher chance that the patient has metastases elsewhere. It also changes the surgical planning; instead of just resecting the tumor, the area of skip lesions needs to be removed as well. We routinely do joint-to-joint imaging for all our bone tumor patients with the specific purpose to assess for skip lesions."



Acute hematogeneous osteomyelitis

9-year-old girl, non-weightbearing, with normal radiographs of the right knee. Infection protocol performed with the SENSE 8-channel Knee coil on Achieva 3.0T. Images show focal marrow edema of the distal femur metaphysis with transphyseal extension (arrows) and juxta-cortical edema (arrowheads).



Juvenile idiopathic arthritis

14-year-old girl with bilateral stiffness in the hips. Infection MRI protocol was performed with SENSE Torso coil on Achieva 3.0T. Images show significant subchondral edema in bilateral hips, affecting the acetabulum and femoral heads (arrows), cartilage loss, joint space narrowing, and hypointense foci within hip effusions consistent with rice bodies (arrowheads).

For joint-to-joint imaging, Dr. Kan typically acquires a T1-weighted scan with the Integrated Body coil. A small coil that fits the tumor size is used for the remainder of the images to provide higher resolution of the tumor itself. These high resolution images are very important to define each fascial compartment and determine if the tumor extends from one compartment to another, or has invaded neurovascular structures.

Other dedicated protocols are made

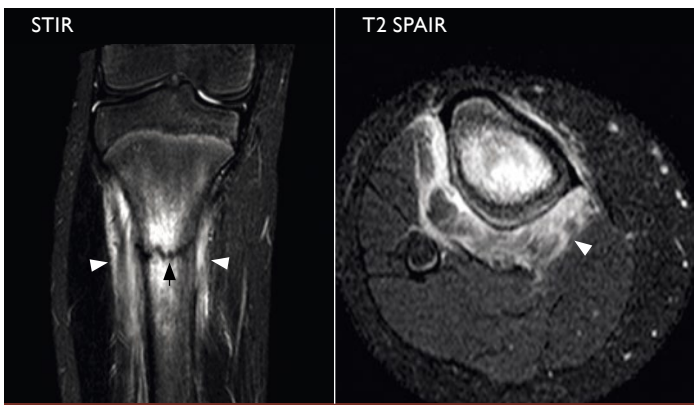
Dr. Kan also uses special protocols for infection, for dermatomyositis and a limited trauma protocol. The limited trauma protocol essentially contains three sequences: fluid-sensitive scans in two planes and a T1-weighted anatomic scan.

"Usually it's a 10-minute study but we can do it in 5 minutes if we have to. For instance, if a child has a calf injury and is non-weightbearing, while plain radiographs are negative, we need to decide whether to put the child in a cast for a radiographically occult (non-visualized) fracture for two to four weeks. In such cases, we can perform a quick, limited MR study," says Dr. Kan. "If that is entirely normal, then we know it's not a fracture, and can look for other reasons that the child is non-weightbearing."

In a current project, Dr. Kan, with the help of Jared Cobb, a graduate student at the Vanderbilt University Imaging Institute of Science, is optimizing imaging of the epiphyseal cartilage in children by using T1 rho research sequences. This is driven by the need to study normal epiphyseal cartilage maturation, evaluating potential growth disturbance related to infection, or to AVN in a very early stage. The T1 rho sequence is sensitive to the amount of proteoglycans within cartilage, and may therefore be useful as a non-invasive exam to assess cartilage quality and development.

Child-friendly atmosphere helps achieve good pediatric imaging

"In addition to high-quality imaging, a child-friendly atmosphere is essential to successful pediatric MR service," says Dr. Kan. "The Children's Hospital building is designed around children, and the personnel specializes in children. We have lots of toys and colorful drawings in our waiting area and hallways. We have a child life specialist who works with both child and family to prepare the child for the MR exam. Our staff members love children, and they have the stamina and the patience to help each child have a positive MRI experience."



Radiologically occult proximal tibia fracture

13-year-old boy, non-weightbearing, with normal radiographs of the right leg. Limited trauma exam with SENSE Cardiac coil on Achieva 1.5T shows non-displaced, acute stress fracture (arrow) of the proximal tibia with significant juxtacortical soft tissue edema (arrowheads).