Optimizing pediatric brain imaging
Application tips

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Pediatric brain MRI is a challenging specialty that requires users to adapt to continually shifting imaging requirements, such as patient size (0.5 to 300 Kg), age, anatomical maturation, pathology, condition, widely varying level of consciousness/cooperation.

Young brains are undergoing myelination, the formation of the myelin sheath around a nerve fiber. Therefore, images of pediatric brains, especially of children under three-years-old, are markedly different from adult brain images. After three years, signal characteristics are similar to those in adult brains, but in smaller anatomy. In children of eight years or older, adult methods are acceptable, as head size does no longer increase appreciably with age.

With the basic strategies described here, high quality pediatric neuro MRI exams are readily achievable. And simple, the way they should be.

Tip 1: Reset the preset for spatial resolution

Preset procedures are designed for healthy, cooperative adult volunteers and therefore usually are inadequate for imaging children. Because the structures of interest are smaller, use the 20%-30% rule of thumb for spatial resolution: reducing voxel sizes by 20%-30% will sufficiently scale adult presets for pediatric patients to optimize spatial resolution.

Tip 2: Adjust contrast parameters for optimal T2W imaging

Users who are new to pediatric MRI, often are challenged by the spectrum of tissue signal characteristics and patient physical sizes encountered among children. For example, unmyelinated white matter in infants is hyperintense on T2-weighted images. This finding is normal at this stage of development.

Optimizing imaging of infants requires adjustment of contrast and resolution parameters. Increasing TR (4000-5000 ms minimum) for T2-weighted scans typically improves contrast, and this alone often is sufficient.

In addition, an increased TE can help exploit the minimal available contrast in infants. As the inherent SNR of T2-weighted TSE is quite high, these adjustments are easily made without adverse effects to overall image quality.

T2 TSE scan of an infant brain shows an example of hyperintense, unmyelinated white matter indicated by the arrows.
**Tip 3: Overcoming T1-weighted imaging challenges with SE**

T1-weighted imaging in infants presents challenges related to the myelination process. Don’t expect to see good T1 contrast in infants – regardless of field strength – as there is not enough white matter in this stage. However, T1-weighted images still can reveal hypoxic ischemic changes well before abnormalities become visible in T2-weighted images. Hypoxic injury results in T1 signal changes in the basal ganglia first, followed by the cerebral hemispheres in more severe injuries.

Among T1 imaging methods, spin echo (SE) is still the gold standard. In infants, SE images tend to be somewhat noisy, but this is normal, especially in neonates, whose brains have ample water but minimal myelin. By the age of three, SE T1 contrast approximates that of adults.

**Controlling flow artifacts in SE**

Flow artifacts in the posterior fossa have plagued post-contrast T1 SE ever since contrast agents were introduced. Hyperintense, contrast-enhanced blood flowing through the transverse sinuses causes bright ghosting artifacts in the cerebellum. While this is seen in all patients, it can be more severe in pediatric patients due to their higher heart rates.

Do NOT add a parallel REST slab to the scan. REST not only is ineffective at suppressing contrast-enhanced flowing blood, but it also reduces T1 contrast through the increased TR needed and through Magnetization Transfer Contrast (MTC) effects. Using a REST slab also may lead to increased motion artifacts due to longer overall scan time.

The only way to reduce flow artifacts in post-contrast T1 SE scans is to use shortest TE combined with a flow compensation gradient.

Use of T1 TSE is not recommended as inherent MTC effects reduce T1 contrast, and the pediatric patient’s inherently low T1 contrast makes it a poor choice.
**Tip 4: Setting up a robust 3D T1-TFE scan**

3D T1 TFE can be a good alternative in terms of resolution, high SNR, and excellent T1 contrast. Additionally, the multiplanar reformatting feature is excellent.

At 3.0T, it offers the best compromise between scan time and image contrast. It provides better T1 contrast than SE, TSE, or T1 FFE, and it’s faster than IR-TSE methods.

Watch TE and pre-pulse delay when modifying 3D T1 TFE, as these can significantly affect the outcome of brain scans.

At 1.5T, fat and water are out of phase every 2.3 ms, while at 3.0T this happens every 1.15 ms. For that reason, with “shortest” TE, little modification may already result in a shortest TE that is out of phase, especially at 3.0T. Setting TE to “in-phase” will avoid this problem.

Similarly, a user-defined pre-pulse delay of 800-1000 ms will guarantee dark CSF and enhanced gray matter/white matter differentiation. Leaving a pre-pulse delay set to “shortest” can have dramatic consequences. Turning on SENSE (factor 2), for example, will halve the shortest pre-pulse delay and CSF will no longer be nulled.

Locking in these two values allows users to freely modify the sequence without negatively impacting image contrast.

**Tip 5: Use optimum inversion delay in FLAIR imaging**

FLAIR imaging can be challenging in pediatric cases due to the lower SNR of inversion recovery techniques. However, because the FLAIR sequence provides so much useful information, accepting a longer scan time can be worthwhile. As usual in MRI, users need to balance scan time, SNR, and resolution.

Left image is a FLAIR adjusted for maximum SNR. The right image is a FLAIR adjusted to high spatial resolution at the expense of SNR. The middle image represents a good compromise.

3D T1 TFE in neonate  3D T1 TFE in 7-year-old

Another great benefit of TFE is flow artifact control, especially after contrast administration.

The 3D T1 TFE images below are acquired after contrast administration. The complete lack of flow artifacts makes diagnosis in these challenging regions a bit easier. When acquiring a midline sagittal as 2D T1 SE, it tends to suffer from flow artifacts arising from the sagittal sinus. The reformatted images show the level of the transverse sinuses, an area that also suffers from flow artifacts when acquired with 2D T1 SE.
When optimizing FLAIR for pediatric patients, the optimum inversion delay depends on the selected TR. As TR increases, also the optimum value for the inversion delay will increase. When a user-defined TR value is between the preset procedures values (6000 and 11000), use the inversion delays of the preset procedures as a guideline for setting the optimum inversion delay.

The high heart rates of small children lead to more flow artifacts compared to adults. Note that the number of packages affects flow artifacts in FLAIR. Dividing FLAIR scans into more packages reduces flow sensitivity. It costs more scan time, but reduces the potential for misinterpretation of images.

Tip 6: Frequency offset test scans aid fat suppression

Fat suppression techniques are very important in pediatrics, for instance when imaging optic nerves in a neurofibromatosis case, or the goal is to find the extent of a lymphangioma.

Pediatric patients are smaller than adults, but conditions such as hydrocephalus, or implants, dental braces or shunts can make fat suppression difficult.

Fortunately, there are some superb tools on Philips MRI systems to optimize fat suppression, for instance volume shim. Also extremely useful are the frequency offset test scans in the “Orbits” folder. These very fast (≈ 9 sec), low resolution scans help to fine tune fat suppression. Just a 36-second investment helps to find the optimum value for the most homogeneous fat suppression in particular patient. Note that the optimum value will change from one patient to the next.

A typical frequency offset test is shown on the right. In this example, the most homogeneous fat suppression occurs with a frequency offset of 80 Hz. This value can be plugged into all fat suppressed scans performed on this patient to achieve the best results.

Although running a frequency offset test is an extra step, it is worth it considering how much time could be wasted if a five-minute high resolution scan would have to be repeated because of poor results.

Note the dramatic improvement between the image acquired with a default orbit protocol and the image obtained with the exact same protocol, after determining the best frequency offset via the test scans.