Answering the Challenges of 3.0T Body MR Imaging

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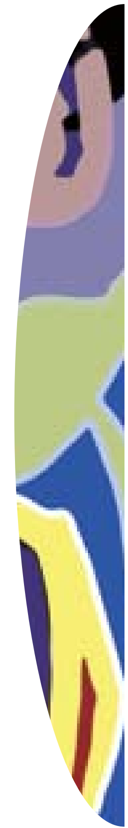

The adoption of body imaging at 3.0T has followed behind applications such as neuro imaging. Concerns over specific absorption rate (SAR), increased sensitivity to magnetic susceptibility, increased chemical shift effects and reduced tissue contrast due to altered tissue relaxation parameters have been partially to blame. Yet, 3.0T has the advantage of increased signal-to-noise ratio (SNR) for higher resolution imaging, which in turn has an adverse effect on scan time.

Considering the majority of body imaging involves breath-hold acquisitions, ARC™, (Auto Calibrating Reconstruction for Cartesian imaging) the newly developed parallel imaging technique by GE Healthcare, is an answer to reduce scan times to an acceptable clinical level. ARC also helps by reducing SAR and susceptibility effects for echo train sequences such as single shot fast spin echo (SSFSE).

Additional advantages of ARC™ for body imaging include:

- Auto-calibration that helps avoid collecting external sensitivity map;
- Less sensitive to field-of-view (FOV) positioning with a tight FOV;
- Clinically practical reconstruction times for continuous scanning; and
- Respiratory triggering becomes practical for parallel imaging.

ROBUST parallel imaging and workflow

ARC can play a key role in body MR imaging by reducing the two most common artifacts – smaller FOV and motion. The auto-calibrating nature of ARC provides workflow simplification and can be seamlessly integrated into sequences without the need for separate calibration scans. In fact, Signa® MR750 3.0T accelerates the very first scan. SSFSE 3-plane localizer now supports ARC.

The acceleration provides two distinct advantages with SSFSE 3-plane:

1. Scan time savings can be used to increase resolution, slice coverage or a combination of both.
2. Shorter echo trains provide sharper images by reducing T2 decay blurring.

These two advantages combined with shorter echo spacing allows higher resolution 3-plane localizer images, which can potentially eliminate the need for an additional coronal SSFSE acquisition.

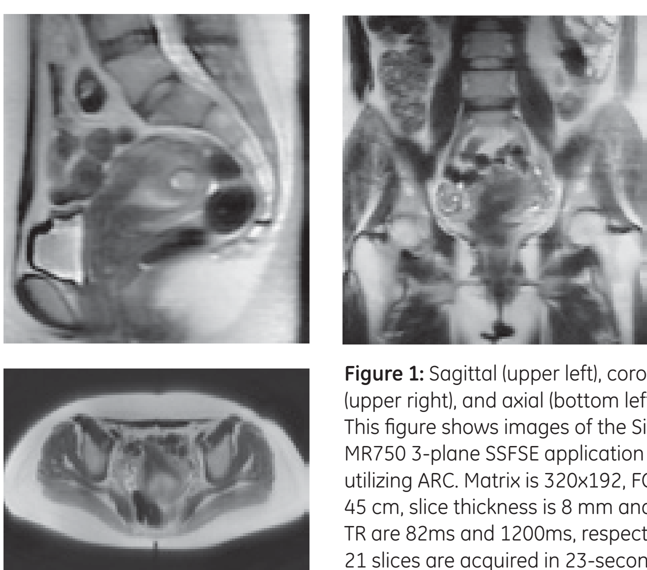

Figure 1: Sagittal (upper left), coronal (upper right), and axial (bottom left). This figure shows images of the Signa MR750 3-plane SSFSE application utilizing ARC. Matrix is 320x192, FOV is 45 cm, slice thickness is 8 mm and TE/TR are 82ms and 1200ms, respectively. 21 slices are acquired in 23-second acquisition using ARC acceleration factor of two.

In-phase and opposed-phase imaging is another critical diagnostic tool for body imaging in assessing fat containing lesions. Signa MR750 introduces the 3D Dual Echo sequence that acquires both in- and opposed-phase in one scan. In fact, 3D Dual Echo is capable of capturing the first opposed-phase TE (~1.2 ms) and first in-phase TE (~2.4 ms). This is critical at 3.0T to eliminate T2* induced signal loss between opposed-phase and in-phase images. Acquiring two echoes within the same scan eliminates potential mis-registration between in-phase and opposed-phase images that can decrease diagnostic confidence. 3D imaging provides sufficient signal to acquire thinner slices and higher in-plane resolution, while ARC provides the scan time savings.

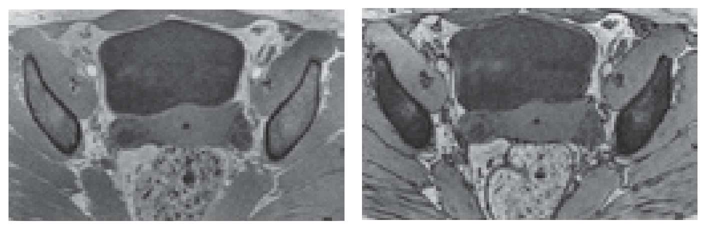

Figure 2: This figure shows images of the Signa MR750 3D Dual Echo application. Matrix 320x320 and 64 slices with 32 cm FOV and 2 mm slice thickness. TE in-phase/opposed-phase (2.6ms/1.3ms) pelvis imaging did not require acceleration.

As a result of these advancements, GE introduces LAVA-Flex on the Signa MR750 3.0T MR system. This sequence is rooted in the 3D Dual Echo imaging technique. It acquires in-phase and opposed-phase images, and utilizes a two-point Dixon technique to reconstruct water contrast and fat contrast images.[1] The user is able to select the output image types: in-phase, opposed-phase, water and fat. LAVA-Flex has the ability to produce four image contrasts with only one scan, allowing the user to reduce the total number of scans per exam. Because water contrast and fat contrast images are synthesized from in-phase and opposed-phase images with shortest possible TEs, effective number of excitations (NEX) for water and fat images is two, providing the maximum possible SNR efficiency.

Aside from the obvious scan time savings, ARC™ offers several unique advantages for LAVA-Flex:

1. Robust Parallel Imaging: Although water contrast images have intrinsic SNR advantage and are free from fat signal, ARC works on lower SNR in-phase and opposed-phase source images, which contain hyper-intense fat signal. Higher SNR in water images affords high acceleration factors, pressuring ARC to perform well with lower SNR source images. Bright fat signal creates higher frequency content in k-space, which is more challenging to resolve with parallel imaging. Potential parallel imaging artifacts on unaliased in-phase and opposed-phase images will show up in the water and fat images. The GE specific ARC technology overcomes these challenges to provide exceptional image quality.
2. Reconstruction Performance: ARC needs to unalias acquired in-phase and opposed-phase images first. Then, two-point Dixon processing is carried out to reconstruct water contrast and fat contrast images. Despite this added overhead, ARC's efficient implementation along with the high-performance Volume Reconstruction Engine (VRE) 2.0 allows LAVA-Flex reconstruction to keep up with the acquisition for contiguous scanning without delays.

3D T1 weighted fat saturation imaging is an integral part of body imaging. LAVA-Flex provides excellent fat suppressed/water contrast 3D T1 weighted imaging. The fat contrast images may then be used for abdominal fat assessments.

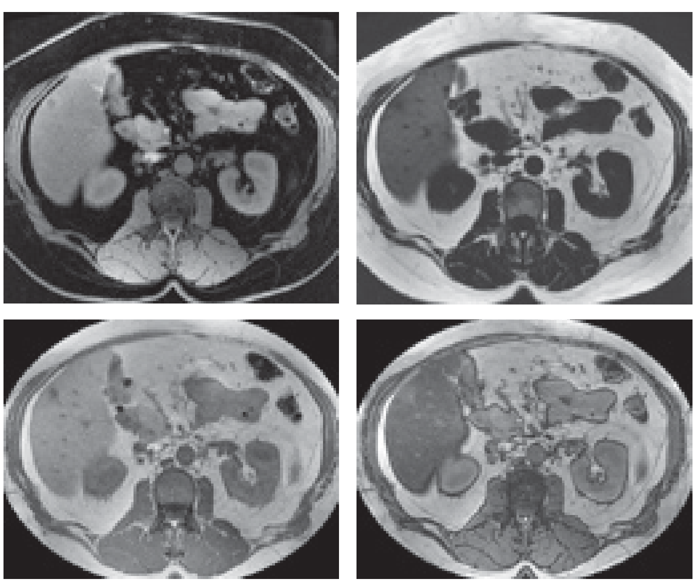

Figure 3: Water (upper left), fat (upper right), in-phase (lower left), opposed-phase (lower right). This figure shows images of the Signa® MR750 LAVA-Flex application. Matrix 320x192 and 52 slices of in-phase (TE=2.6 ms) and opposed-phase (TE=1.3 ms) with 36 cm FOV and 4 mm slice thickness are acquired in 21 seconds using ARC™ acceleration factor of two.

ARC is also compatible with the following three widely used abdomen applications:

1. LAVA is widely known for its superb 3D fat suppressed T1-weighted imaging for body applications. ARC provides extra confidence that image quality and consistent results are maintained.
2. FRFSE-XL T2 weighted sequence is routinely used for abdominal imaging. The user defines either a breath-hold, or a respiratory-triggered acquisition. ARC parallel imaging is a perfect fit for respiratory-triggered imaging due to its auto-calibrating characteristics.
3. SSFSE imaging benefits from the implementation of ARC as well. As in the 3-plane implementation, parallel imaging reduces echo trains, providing sharper images and reducing T2 decay blurring, as well as reducing scan times.

ARC improves imaging at 3.0T by enhancing workflow and at the same time increasing image quality. With new imaging techniques such as 3D Dual Echo and LAVA-Flex, body imaging takes a leap forward on the Signa MR750 3.0T. ■

"LAVA-Flex is a robust sequence that offers 'fat only' and 'water only' images in addition to excellent in-phase and opposed-phase images in a single breath-hold. This sequence has quickly become a routine part of all our abdominal sequence protocols at 3.0T."

Elmar Merkle, MD,
Professor of Radiology, Head of Body Magnetic Resonance Imaging and Medical Director of the Center for Advanced Magnetic Resonance Development at Duke University

References

1. Jingfei Ma, Breath-hold Water and Fat Imaging Using a Dual-Echo Two-Point Dixon Technique With an Efficient and Robust Phase-Correction Algroithm. MRM, 52:415-419, 2004.