Consistent, Reliable, Fat-Suppressed Imaging Even with Difficult Anatomy

In MR images, fat appears bright and can obscure or mimic pathology, so most clinical protocols use methods to suppress fat, improving the conspicuity of underlying abnormalities. There are many instances, however, where it would be advantageous for clinicians to directly visualize fat. For example, when imaging a tumor containing fat, the typical protocol is to obtain images with and without fat suppression.

To provide robust, water-only images that also retain important information from fat, it is critical to have methods for robust, uniform separation of water and fat. Some limitations of traditional fat suppression techniques are outlined in the adjacent sidebar. Perhaps most important to note with these techniques, all fat signal is lost along with useful diagnostic information.

To address this need, GE Healthcare developed a new technique, IDEAL*, in collaboration with the University of Wisconsin and Stanford University. It is available for use on the Signa HDx 1.5T and 3.0T MR systems.

Scott Reeder, M.D., PhD, Division Chief of MRI, University of Wisconsin-Madison Hospitals and Clinics, is one of the inventors and patent holders for IDEAL. "IDEAL is robust in challenging areas," Dr. Reeder said. "We can achieve excellent fat suppression and also directly visualize the fat imaging."

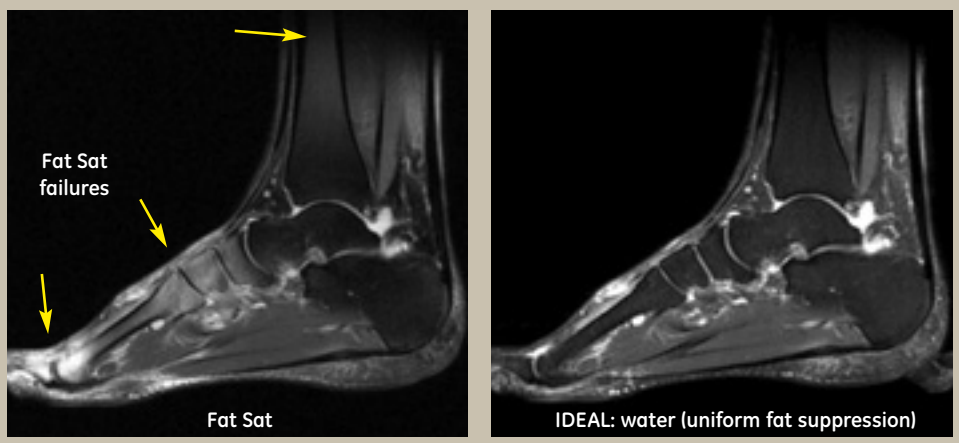
The technique is related to traditional 3-point Dixon methods, acquiring three images at slightly different echo times to generate phase shifts between water and fat. Although three echoes are necessary, the effective number of excitations (NEX) for the water and fat images is three; therefore, IDEAL has the maximum possible signal-to-noise (SNR) efficiency, using all images efficiently in the separated water and fat images.

According to Dr. Reeder, the key advantage of IDEAL is the ability to use parallel imaging. "We can't use parallel imaging with traditional 3-point Dixon methods." Also, IDEAL is compatible with the newer generation of phased array coils and optimized for the best possible SNR. With IDEAL it is also possible to use arbitrary echo spacing and arbitrary numbers of echoes (N>=3), while Dixon methods are limited to images acquired when water and fat signals are acquired in and out of phase. As a result, the echo shifts are optimized for the highest possible SNR performance, which further accelerates the acquisition. "The SNR penalty with parallel imaging is offset by the increased SNR with IDEAL," he added.

Limitations of traditional fat suppression techniques

- Spectrally selective fat sat methods fail in challenging anatomical areas, such as the neck, extremities, off-isocenter imaging, and large field-of-view (FOV) imaging. This is due to local magnetic field inhomogeneities caused by susceptibility differences at air-tissue interfaces and by the unfavorable geometry, or inhomogeneities, induced by the presence of metallic implants. Failed fat saturation can also cause inadvertent saturation of the water signal (the signal of interest), obliterating important anatomy or pathology and rendering images non-diagnostic. Spatial-spectral or "water-excitation" pulses suffer from the same drawbacks as fat-saturation methods.
- Short TI recovery ("STIR") imaging uses an inversion pulse to null short T1 species such as fat, but in the process alters contrast and reduces SNR. STIR images are inherently T1 weighted, and should not be used for post-contrast imaging because the shortened T1 of enhancing tissue may cause inadvertent suppression of important pathology. STIR provides very uniform fat suppression and is commonly used with T2 weighted imaging; however, the poor SNR performance and inability to perform post-contrast T1 weighted imaging are highly limiting.

*IDEAL: Iterative Decomposition of water/fat using Echo Asymmetry and Least-squares estimation

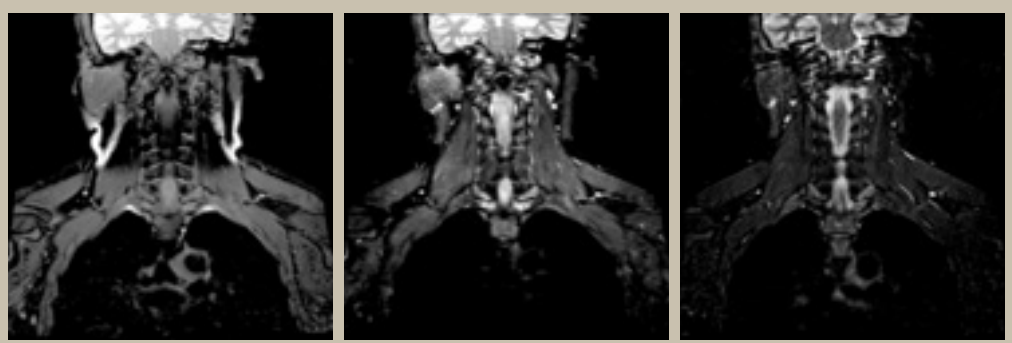


Another advantage of IDEAL is its ability to capture high quality images in a point-and-shoot way. Dr. Reeder said, "Fat can be consistently and reliably separated from water. This can lead to a decrease in the number of sequences within our protocols." He also noted the reliability of IDEAL reduces the need to repeat scans that previously resulted from failed fat saturation with traditional methods or STIR. In addition, the separated water and fat images can be recombined into "in-phase" and "out-of-phase" images, which are commonly acquired as two separate acquisitions. This should further reduce overall protocol time and provide additional information to the radiologist.

A third benefit of IDEAL is the elimination of artifacts, and chemical shift. In-phase, or non fat-suppressed, images are corrected for chemical shift misregistration of fat, thereby allowing low bandwidth acquisitions and reduced NEX. Dr. Reeder notes that the higher SNR with less artifact produces higher quality images that give the radiologist more confidence.

"IDEAL can unambiguously identify water and fat," he added. Water, fat, in-phase and out-of-phase images are inherently co-registered, which can lead to faster interpretation and higher diagnostic confidence, particularly in difficult areas of anatomy such as:

- Orbits
- Brachial plexus
- C-spine
- Extremities (ankle/wrist/foot)
- Off iso-center applications (shoulder/hip)



Brachial Plexus Imaging – 1.5T, PD Weighted, 2D Fast Spin Echo

Scott Reeder, M.D., PhD, is Division Chief of MRI, University of Wisconsin–Madison Hospitals and Clinics.

About University of Wisconsin-Madison

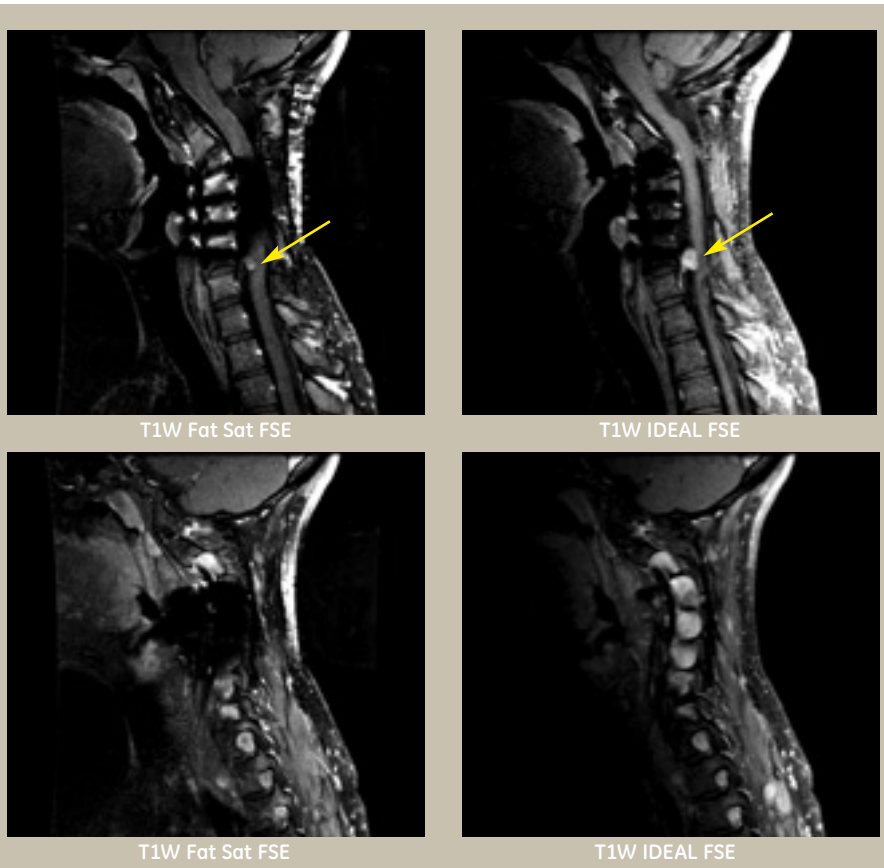
UW Health, the academic health system for the University of Wisconsin, offers more than 60 locations throughout the state, including the renowned University of Wisconsin Hospitals and Clinics and University of Wisconsin Children's Hospital in Madison. This comprehensive system of healthcare providers serves patients at more than 60 clinical locations throughout the state. University of Wisconsin Hospitals and Clinics is a 471-bed facility that ranks among the finest academic medical centers in the United States.

The University of Wisconsin Hospitals and Clinics offers more than 800 active medical staff and more than 80 outpatient clinics. The hospital has six intensive care units (trauma and life support, pediatric, cardiac, cardiothoracic, burn, neurosurgery) with 74 total beds, and is one of only two organizations in Wisconsin with designated Level One adult and pediatric trauma centers.

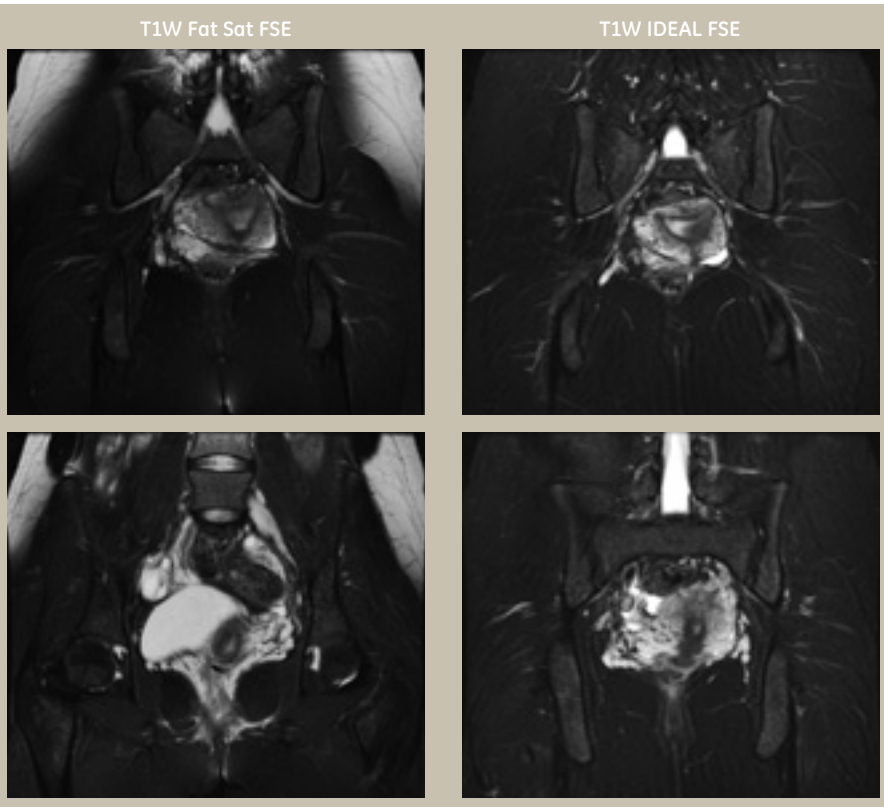
Clinical Applications

A common indication for MR imaging is for the detection of masses. For example, in the female pelvis, endometriomas are often bright on T1 weighted imaging, while an ovarian dermoid has fat, which also appears bright on T1 weighted imaging. Most MR imaging protocols include two T1 weighted sequence scans – one with and another without fat supression. "With IDEAL, it requires only one acquisition to separate both water and fat signals," Dr. Reeder said. "We can help increase the level of diagnostic confidence by directly visualizing the fat. This is a unique capability of IDEAL."

Another difficult imaging area is the brachial plexus. This critical area of the anatomy is prone to the invasion of lung tumors (eg. Pancoast tumor). "Using traditional fat saturation methods, MRI tends to fail in this area," Dr. Reeder explained. "We don't use STIR because it is incompatible with post-contrast T1 weighed imaging and its poor SNR performance." IDEAL, he said, is an excellent solution for this clinical study. ■



Post-surgical Cervical Spine: Neurofibromatosis



Coronal Fse-xl T2 fat suppressed images (fov 30cm) demonstrates inhomogeneous fat suppression in the slice anterior–posterior direction

Benefits of IDEAL

- **Patient** – potentially reduce "on the table" scan time,
- **Technologists** – reduce number of repeat scans
- **Radiologists** – higher diagnostic image quality for increased confidence
- **Administration** – potential for increased throughput
- **Referring physician** – better image quality