Non-Contrast MR Arthrograms Generate Exquisite Images

The advantages of fully-balanced gradient echo techniques (b-SSFP, b-FFE, FIESTA, true-FISP, etc.) have been well established over the past several years. Fully balanced pulse sequences result in all of the gradient moments being integrated to zero over the TR. This provides a high Signal-to-Noise Ratio (SNR) per unit time and an excellent Contrast-to-Noise ratio (CNR). However, due to the lower ratio of T2/T1, the soft tissue contrast provided by b-SSFP techniques is only suitable for several specific clinical applications.

In any balanced acquisition, after the initial RF pulse the MR signal tends to fluctuate or "oscillate" during the transition to a steady-state period. Without special preparatory sequences, the period of signal oscillation is quite long and requires a number of "dummy" RF pulses to occur before imaging can be achieved. These dummy pulses are designed to make the signal "settle". Recent developments in variable RF flip angle preparation schemes have resulted in much shorter transitions to this steady-state period, ultimately leading to more efficient imaging.

Instead of ignoring this transition or oscillatory period, 3D COSMIC™ (Coherent Oscillatory State acquisition for the Manipulation of Image Contrast) exploits the unique properties of the MR signal evolution in order to generate the desired soft-tissue contrast. During this initial period, soft tissue exhibits an elevated T2/T1 signal component, which can be captured to yield a high CNR of those structures. To minimize ghosting and blurring artifacts, the unique variable-flip angle RF pulse train is used at the beginning of each segment to minimize the signal oscillations that would otherwise occur during the transition period (Figure 1).

Figure 1. Pulse sequence timing for a 3D COSMIC acquisition. The RF prep and RF post segments improve the oscillatory signal state while the recovery period aids SNR by allowing recovery of the longitudinal magnetization.

This results in maximized T2/T1 contrast from the soft tissues. Following this short preparation sequence, the image data is acquired. The data acquisition occurs while the signal is transitioning to steady-state. 3D COSMIC™ uses segmented centric ordering to capture the majority of the unique signal properties within the center of k-space. A true elliptical sampling of the k-space data is used where the corners of the k-space volume are zero-filled outside of a given k-space radius. This saves time – approximately 30 percent – and minimizes aliasing artifacts while maximizing image resolution.

To further improve the signal stability, a separate variable-flip angle RF pulse train is used following the acquisition period. Additionally, a recovery period is used to allow the longitudinal magnetization time to recover between segments, thereby improving SNR.

A. Joseph Borelli, Jr., MD, uses 3D COSMIC for arthrography studies. Dr. Borelli notes several benefits of the sequence, including:

- Short scan times of two to three minutes;
- High through-plane resolution, typically 2.0 mm zipped to 1.0 mm;
- High in-plane resolution (500-800 microns);
- Inherent high SI of joint fluid, making the use of gadolinium contrast unnecessary; and
- Insensitivity to vascular pulsation artifacts.

The following images from Dr. Borelli depict the excellent soft tissue visualization capabilities of 3D COSMIC without the use of gadolinium contrast. ■

Dr. A. Joseph Borelli, Jr.

A. Joseph Borelli, Jr., MD, is President and Medical Director of MRI at Belfair, LLC, in Bluffton, SC. He has developed MRI facilities in the northeastern and southeastern US. He also served as Assistant Clinical Professor of Radiology at the Medical University of South Carolina.

Dr. Borelli received a BA in chemistry at the University of Pennsylvania. He attended Hahnemann University School of Medicine in Philadelphia. He completed his residency at the University of Oklahoma Health Sciences Center and his MRI fellowship at the University of Pittsburgh Medical Center. Dr. Borelli is chairman of the American College of Radiology's committee on MRI accreditation.

Images courtesy of Belfair LLC.

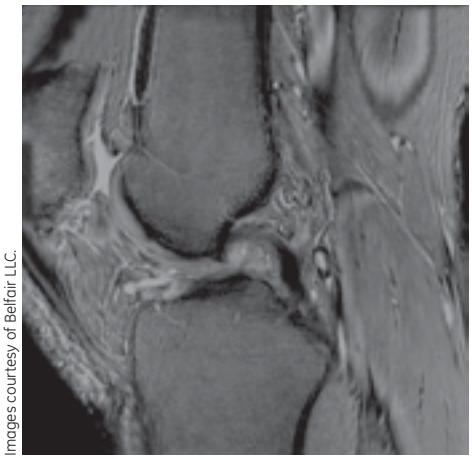

Figure 2. Note the extremely high SI of joint fluid, highlighting Grade 3 patellar chondromalacia.

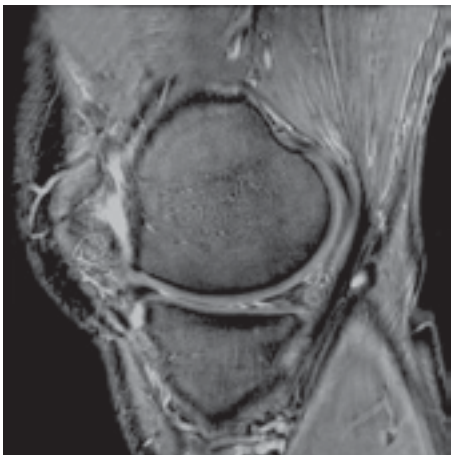

Figure 3. Exquisite demonstration of complex meniscal pathology, which cannot be viewed with a typical three to four mm slice thickness.

Figure 4. Note the beautiful arthrographic effect in the wrist, showing intact scapholiunate and lunotriquetral ligaments.