49 Dual-Echo Steady State (DESS)

A further modification of steady-state gradient echo technique involves the acquisition of two different echoes during each repetition time. The first echo is the free induction decay (FID) gradient echo used in the spoiled GRE sequence (Chapter 35) and the second is the RF echo (SE) used in the PSIF sequence (Chapter 52). The separation and acquisition of these two echoes are illustrated in **Fig. 49.1**. As noted previously, the signal decay after excitation is called the FID and can be sampled with any gradient echo technique. Any RF excitation pulse also has refocusing capabilities. An echo that is formed using a refocusing RF pulse is called a spin echo (SE). With DESS, each RF pulse generates an FID and a SE signal in the steady state. In the pulsing diagram shown in **Fig. 49.1**, the gradients are employed such that for the first echo, the FID is rephased and the SE is spoiled, and for the second echo, the reverse is true—the FID is spoiled and the SE is rephased.

The DESS sequence starts with a slice selective low-angle excitation pulse (1 in **Fig. 49.1**), with the FID sampled (2 in **Fig. 49.1**) as per the GRE techniques described previously. The remaining transverse magnetization, previously dephased with a phase encoding gradient for the purpose of spatial encoding, is then refocused for that direction. The transverse magnetization is prepared in the direction of slice selection to be refocused in the center of the next excitation pulse to form a spin echo (3 in **Fig. 49.1**). The dephasing mechanism of the slice selection gradient is at this point considered in advance. The frequency-encoding gradient is left on for the period of both echoes (4 in **Fig. 49.1**) and is incompletely balanced to avoid dark banding artifacts otherwise associated with fully balanced steady state sequences. Note that the effective TE for the spin echo contribution is actually longer than TR. The FID and SE components are sampled in adjacent windows and combined prior to image reconstruction.

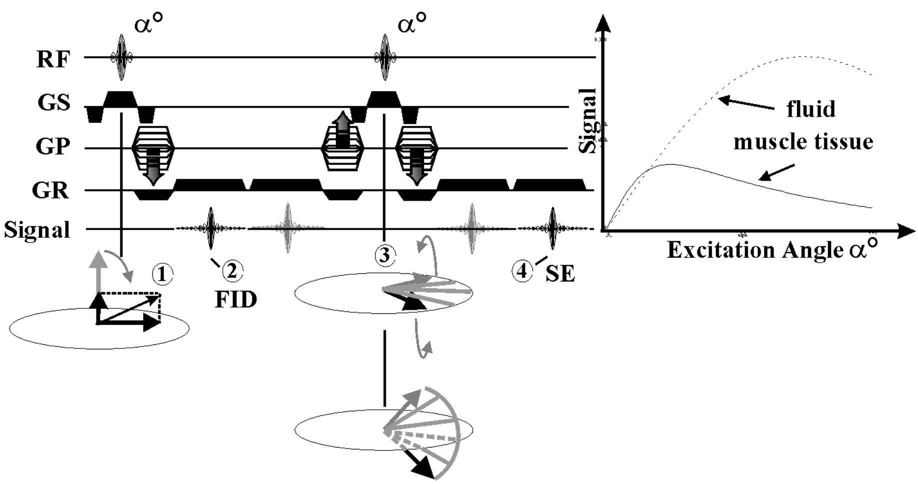

Fig. 49.1

Advantages to this approach include improved SNR and somewhat unique contrast (due to acquisition and subsequent combination of the more T1-weighted spoiled GRE echo and the T2-weighted RF echo). Measurement times are comparable to refocused steady-state GRE technique. It should be noted that DESS is actually not that much different from a refocused GRE sequence (FISP), but because two echoes are sampled, it will typically have better SNR. Also, both DESS and FISP will have both T1 and T2 components (weighting) due to the contribution of the rephased spin echo signal. Applications for DESS include high-resolution 3D imaging of the joints permitting high-quality multiplanar reformats, with high signal intensity for fluid, and excellent delineation of cartilage and bones. Thus, it is used in orthopedic imaging and MR arthrography. Note that due to the combination of T1 and T2 contrast, the use of this technique is restricted in terms of the detection of pathologies with a diffuse distribution pattern such as bone edema or infiltrative masses.

Fig. 49.2 presents multiplanar reconstructions from a 3D DESS sequence acquired on a 3 T system using an 8-channel extremity coil. The DESS sequence acquired provided a high-resolution dataset of the knee with a voxel size of $0.5 \times 0.5 \times 0.5$ mm^3. The small isotropic voxel permits reconstruction of high-quality multiplanar reformatted images in any desired plane, demonstrating well even small anatomical structures. Sample reformatted images with a slice thickness of 2 mm are presented in **Fig. 49.2** in the anatomic sagittal (a), coronal (b), and axial planes (c), together with an oblique plane adapted to visualize the anterior cruciate ligament (d).

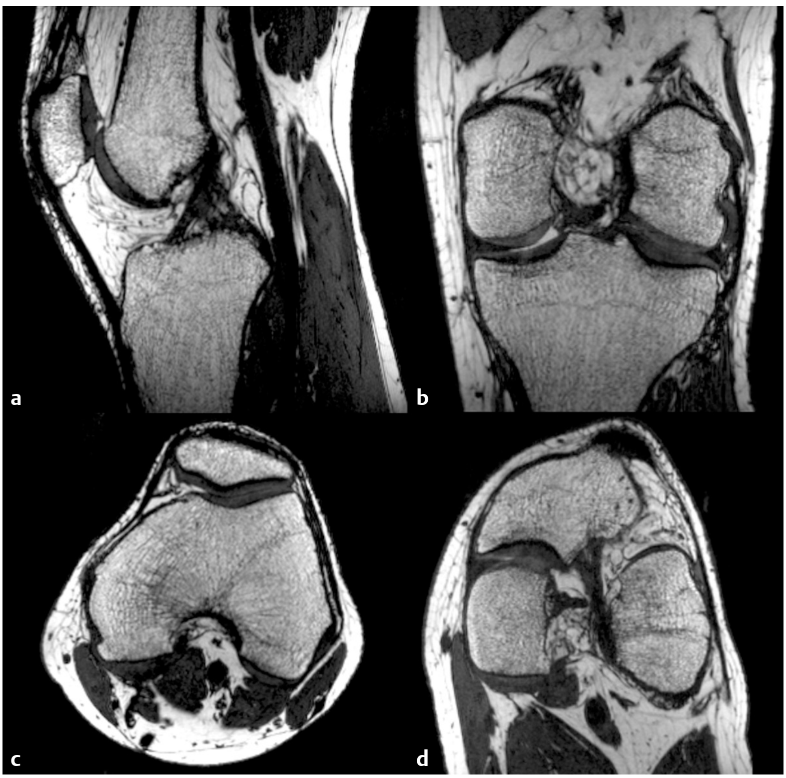

Fig. 49.2