Non-Excitory Steady-State Interference Elimination (NESSIE) MRI Fiducial Tracking

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Introduction. Resonant micro-coil fiducial markers [1, 2] used for instrument tracking in interventional MRI may be directly connected to the MR receiver system, e.g as part of an array element, or inductively coupled and detected via a standard MR receiver coil. The advantages of inductive coupling are simplicity and increased patient safety due to the lack of cabling required. The disadvantage is that the fiducial coil retransmits the RF transmitter pulse magnified by the quality factor Q with a 90° phase change [3], thus the actual flip angle experienced by the MR sample in the fiducial is unpredictable, as will be its appearance within the image, in extreme cases either dominating the dynamic range or being invisible. This is shown in figure 1 for a FLASH sequence. Non-Excitory Steady-State Interference Elimination (NESSIE) pre-saturation removes this sequence dependence for inductively-coupled fiducials.

Methods. The fiducial coils consisted of 6 turns of 0.46mm diameter enameled wire wound around a 2.3mm diameter former with an inductance of about 55nH tuned to 63.8 4MHz with a series capacitance of 110pF. The coil was filled with a 2mm sided cube of commercially-available vinyl plastisol gel material (Spenco) which has MR properties equivalent to those of water.

As proof of concept, the NESSIE sequence was implemented on a Siemens 1.5T Magnetom Vision scanner (VB33G), prefixed to a standard gradient echo sequence (FLASH). In NESSIE a single or a short train of very small flip angle pulses α_N is applied non-selectively, each separated by time TD followed by spoiler gradients (Figure 2). Because of the local retransmission of the RF, the fiducial sample will experience a larger flip angle and can be saturated out whilst leaving the rest of the image unaffected.

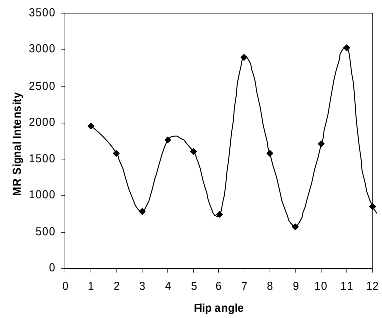

Figure 1

The fiducial was placed within a circularly polarized head coil at the scanner isocentre on top of a spine phantom containing an aqueous solution of nickel sulphate with T_1 and T_2 approximately equal to 300 ms. Scan parameters were: field-of-view 300mm, matrix 256x160 (5/8 rectangular field-of-view), slice thickness 6 mm, flip angle $\alpha = 40°$, bandwidth per pixel 488 Hz. TE was 2.2ms with TR = 15.1 ms. The NESSIE flip angle α_N was varied from 0 to 5 degrees. Scan time for a single slice was 2.4s.

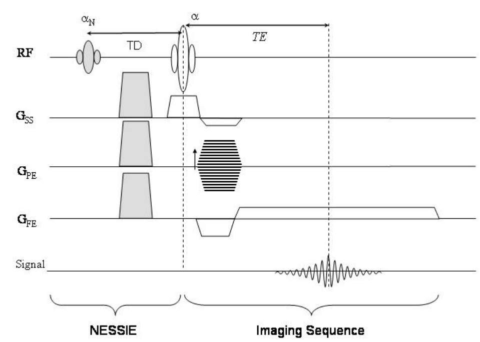

Figure 2

Results. Figure 3 shows the NESSIE flip angle dependence of the fiducial and background phantom for FLASH. α_N = 2-4° gives saturation of the fiducial signal. Figure 4 shows images for optimum visualization of the fiducial and its removal (α_N = 3° and 0°).

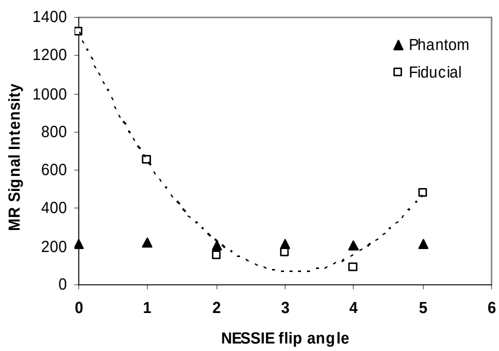

Figure 3

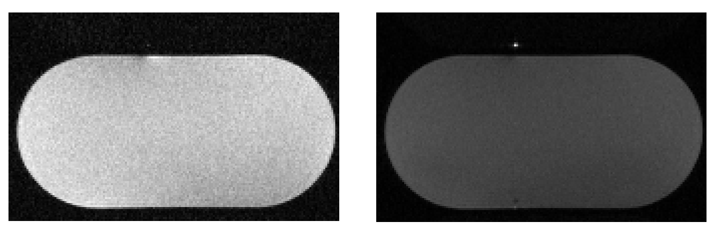

Figure 4

Conclusions. By applying a short pre-saturation of small flip angles, it is possible to independently control the image appearance of inductively coupled fiducial markers with respect to the image background. The technique has been implemented for a spoiled gradient echo technique. It is possible to implement it for other types of MR pulse sequence enabling control over their appearance for a range MR diagnostic pulse sequences to enable reliable device tracking for MR guided surgical procedures or biopsies

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References

1. Coutts GA *et al*, *Magn Reson Med,* 1998, 40(6):908-13.
2. Burl M *et al*,, *Magn Reson Med,* 1996; 36:491-4936.
3. Hoult DI, Tomanek B, *Concepts in Magnetic Resonance* 2002; 15, 265-282.