Rapid angular measurement using MAMBA

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Introduction

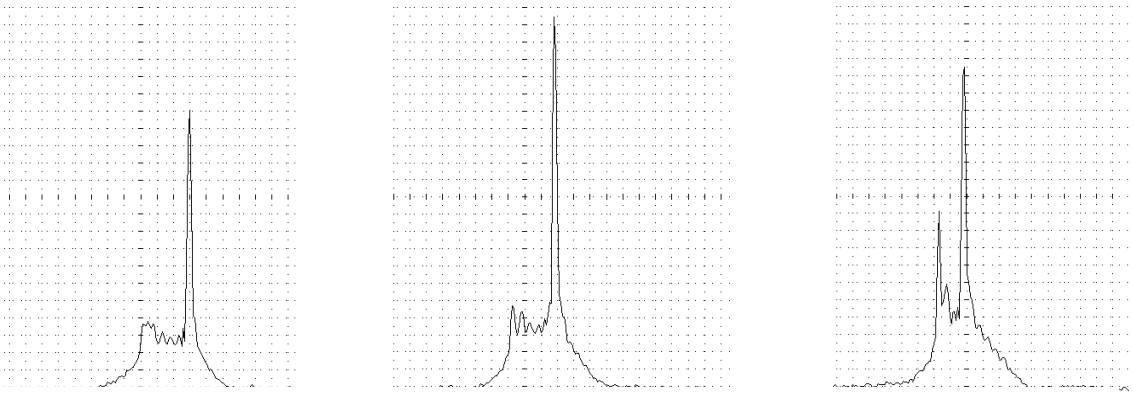
Rapid determination of the angulation of a plane may be useful, for example, in targeting the trajectory of a needle during a biopsy procedure or in measurement of the planar head rocking motion commonly found in neonates. A small solenoidal coil with a length to diameter ratio >~ 3:1 can be used to give an accurate measurement of the angle between the coil and the direction of B_0 (linear over a limited range) due to the cosine dependence of the frequency shift generated by the field from the coil (1).

Methods

A solenoidal coil of length 30mm was wound around a 5mm diameter, 35mm length tube containing water and was supplied with 100 mA of current from a filtered laboratory power supply. The device was located within one 100mm diameter coil of a TMJ phased array coil on a 1.5T Infinion MR system (Philips Medical Systems, Best, NL) and spectra acquired using a spin echo spectroscopic acquisition with a bandwidth of 1-15KHz, a repeat time of 300 ms and an echo time of 10 ms with NEX = 1. The coil arrangement was rotated with respect to B_0 and the angle measured using a protractor to within approximately 2^0. The second coil of the TMJ array was attached to a phantom which was also rotated by the same angle with respect to the field but was located sufficiently far from the angular device so that signal cross talk did not occur between coils A spin echo image of the phantom (TR 300ms, TE 20ms, resolution = 1mm, SLT =5mm, NEX =1) was acquired with the oblique angulation predicted by the MAMBA measurement.

Results

Figure 1 shows magnitude spectra at angles of 10, 40 and 70 degrees to the main field rotating from the the z axis along B_0 to the x axis. The increasing shift of the spectral peak as the angle of the coil to the field reduces can be clearly seen. Similar results were acquired by rotating from y to z. However, rotation in the x-y plane did not produce a significant shift as the coil maintained a 90 degree angle to B_0. Frequency shifts up to 0.13ppm/degree were obtained, dependent on applied current and sampling bandwidth, which were approximately linear over a 60 degree range. The angular measurement was approximately independent of position within the uniform field volume due to the high magnet uniformity. The data was used to guide the oblique acquisition plane for a phantom on a 1.5T MR system (Philips Eclipse, Cleveland, USA) to provide a check on the angular measurement.



Discussion

A simple coil device can be configured to give an accurate measurement of the angle between the axis of the coil and B_0 which is approximately linear over a wide angular range. An oblique plane was accurately selected to within 2-3 degrees using the angular information from the MAMBA probe. As an alternative to use of a dedicated receiver coil, shift of the frequency signal to the noise region at edge of the spectral bandwidth could be used to separate the angular measurement signal from the main image data, assuming sufficient dynamic range. The lack of translational information may be a problem in certain applications, but the method is capable of very rapid angular determination in a single FID without the use of switched field gradients. The 'MR proctractor' may be useful for rapidly determining alignment of limbs for Magic Angle imaging studies and multiple coils could be used when several articulations need to be measured simultaneously.

[1] Lee KJ et al., 2002. Magn Reson Imaging; 20: 119-125.