PROPELLER with Echo Stabilization

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PROPELLER has been widely used in the clinic for T2-weighted neuro imaging due to its capability for correcting motion artifacts (1). Recently its application has been extended to body and musculoskeletal (MSK) studies because of its inherent insensitivity to motion. As an FSE-based technique (2), PROPELLER faces similar issues as FSE, e.g., the violation of the Carr-Purcell-Meiboom-Gill (CPMG) condition due to various causes. One solution employed by FSE is to perform phase correction that compensates for phase error to satisfy the CPMPG condition in order to stabilize the signal in the echo train (3). However, its application on PROPELLER is not straightforward due to the rotation of the blades. In this work, we propose a model-based phase correction to stabilize the echo train signal for PROPELLER. This greatly improves the image quality, especially for MSK imaging.

THEORY FSE (and PROPELLER) utilizes the CPMG condition to generate the echo train signal. It is susceptible to phase errors caused by B0 field inhomogeniety, eddy current, gradient fidelity, etc. FSE phase correction uses the signal its self to estimate and compensate for the phase error. In PROPELLER, since the blade is rotating throughout the acquisition, each blade is subject to different phase error. One can measure the phase error at each blade, but this is time consuming and not acceptable in the clinical environment. However, one can also measure the phase error at a limited number of blade angles and then predict the phase errors at other blade angles. The key is the model that can accurately depict the phase error behavior with respect to blade angle since it is not strictly sinusoidal. Based on the experimental data, the following model is proposed,

$$\Delta\emptyset = c_0 + \sum_{i=x,y,z} G_i \cdot [(G_i \geq 0)?\, c_{i1}\colon c_{i2}]$$

Where G_i is the gradient amplitude on a physical axis, c's are the 0^{th} and 1^{st} order coefficients. Worth noting here is the dependence of 1^{st} order coefficients on the polarity of the physical gradient, which is partially contributed to the nonlinearity of the eddy current, b0 inhomogeneity, etc. For a generalized scan, measurement at a minimum of 6 blade angles is needed for the estimation (one axis can be kept at the same polarity by choosing appropriate rotation angles).

Three sets of in-vivo wrist data were acquired, including 1) data with blade angle rotating in - π~π as reference for phase error, data 2) without and 3) with the proposed phase correction. To better demonstrate the performance of the phase correction, the eddy current is artificially increased.

RESULTS AND DISCUSSION Figure 1 shows the constant phase errors. The blue line shows the actual measured phase errors at 20 blade angles. The red line shows the estimation calculated from the 6 source data points (red asterisk). The estimates match the actual measurement very well.

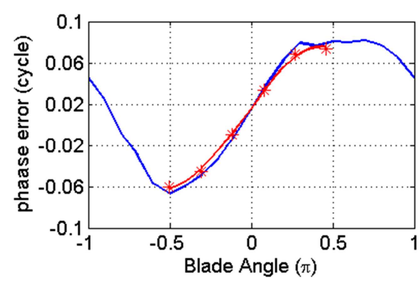

Fig. 1 Measured (blue line) and predicted phase error (red line) estimated from 6 measured points (red asterisks).

Figure 2 shows the in vivo images a) without and b) with the proposed phase correction. c) is the FSE image with phase correction as reference. It can be seen that phase correction greatly improves the image quality.

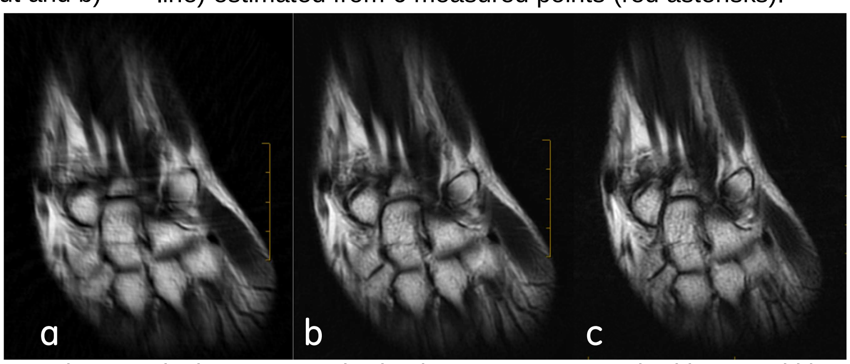

Fig. 2 Wrist images acquired using PROPELLER a) without and b) with the proposed phase correction. c) is the FSE image with phase correction as reference.

In summary, a model-based phase correction for PROPELLER is presented to stabilize the echo train to improve the image quality. This is especially desirable for imaging anatomies that are off the iso-center..

REFERENCES

1. Pipe et al. MRM 42:963, 1999.
2. Hinnig et al. MRM 3:823, 1986.
3. Hinks et al. SMR abstract 3:634, 1995.