Improved A-P Parallel MRI of the Spine using a Twisted Array

S. B. King[1], S. Vijayakumar[2], F. Huang[2], C. Saylor[2], G. R. Duensing[2]

[1]Institute for Biodiagnostics, National Research Council of Canada, Winnipeg, Manitoba, Canada, [2]In Vivo Corporation, Gainesville, FL, United States

Introduction

For surface arrays such as spine coils, the goal is to provide maximum SNR and minimum g-factor at a particular depth of interest. Over the past few years, the best array construction method of improving g-factor was with separated array elements [1], but this also causes SNR loss between elements, especially in arrays with separations along the S-I direction [2]. Spine MRI tends to be done with A-P phase encoding, without the speed-up benefit of parallel MRI, because traditional spine arrays do not have adequate g-factor performance for A-P phase encoding. Recently, the Twisted Array [3] was shown to allow improved g-factor for S-I phase encoded parallel MRI, without the SNR loss associated with separated array elements. In an attempt to provide A-P speed-up in spine MRI, we will study A-P g-factor and SNR performance of a new Twisted Array and compare to standard spine array coils.

Theory/Methods

In order to maintain SNR gain while stacking array elements over the same FOV, they should be substantially orthogonal in resistive/inductive properties. In the Twisted Array design [3], the twisted loop and twisted butterfly elements are centred in the gaps between separated loop-butterfly elements. The lobe dimensions are chosen such that the twisted array element is naturally isolated from all loop and butterfly elements, and so that SNR gain and reduced g-factor is achieved at the depth of interest. For g-factor and SNR predictions, quasi-static numerical simulations were performed (sagittal slice, z-FOV=35cm, y-FOV=25cm) for 3-loop/butterfly elements (6-channels) with 10% gap, an 8-Ch. Twisted array by adding 2-twisted-loops, and a 10-Ch. Twisted Array by further adding 2-twisted-butterfly elements. A constructed 8-channel twisted array consisted of 2-twisted loops one of each centred about the two 10% gaps between 3-loop and 3-butterfly elements. Images (SE, TR/TE=300/10ms, z-FOV=34cm, y-FOV=17cm) were collected on a GE 1.5T 8-channel MRI system with the Twisted array and a 6-channel OEM spine array of overlapped loop/butterfly elements.

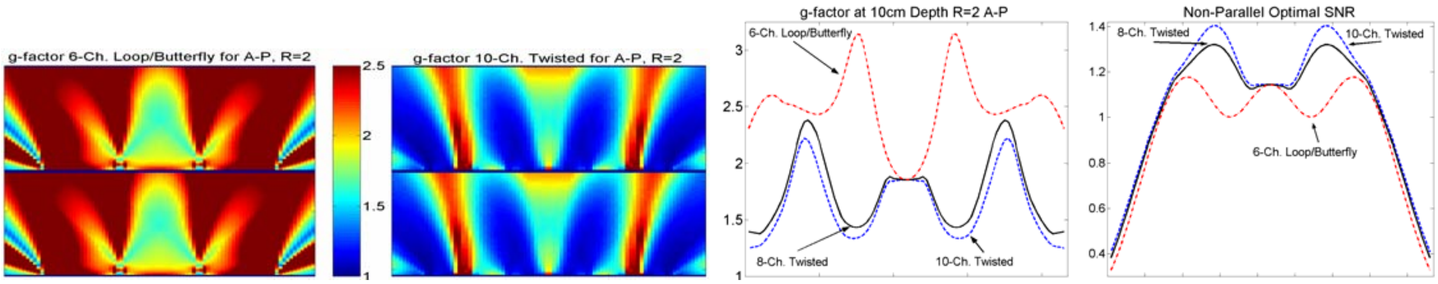

Fig. 1: Simulated A-P phase encoding R=2 g-factor maps (*left*) profile at 10cm (*middle-right*) and non-parallel optimal reconstruction SNR (*right*).

Results/Discussion

Both simulated (*Fig.1*) and experimental (*Fig.2*) g-factor maps show a substantial improvement in g-factor when using the Twisted Array (*Fig.1-left*) compared to loop/butterfly arrays, particularly at the depth of interest (*Fig.1-middle-right*). For instance, simulations suggest that in the “gap” region, the A-P R=2 g-factor can be reduced from 3.2 to an acceptable 1.4 using the Twisted Array. Because the lobe sizes (in particular the central lobe) within the twisted array element are comparable to the optimum loop-size for a particular depth, Twisted-Loop and Twisted-Butterfly array elements show significant inherent SNR at the depth of interest, leading to significant SNR gains (30%) in the “gap” region when combined with standard loop-butterfly elements (*Fig.1*:*far-right*).

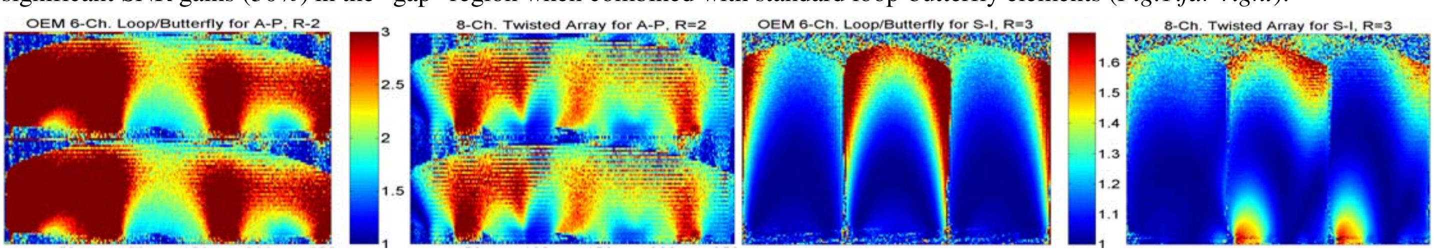

Fig. 2: Experimental A-P phase encoding g-factor maps for R=2 (left), and experimental S-I phase encoding g-factor maps for R=3 (right).

Conclusions

The Twisted Array demonstrates improved g-factor not only for parallel MRI in the S-I direction (g<1.3), but now also for A-P parallel MRI. This adds to the Twisted Array’s ability to improve S-I g-factor and SNR at the depth of interest, particularly in the gap or overlap region, while minimizing the number of Rx-channels. It may now be feasible to perform R=2 speed-up in the A-P direction for spine MRI. Further research will focus on g-factor minimization by optimizing the loop-gap of such Twisted spine arrays.

References

[1] M. Weiger et al. MRM 45:495-504(2001). [2] C.J. Hardy et al. MRM 52:878-884(2004). [3] S.B. King, Proc. ISMRM p.675(2005).