A 16-channel Arterial Spin Labeling - Head Transceiver Array Combination for 7 Tesla

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Target Audience: RF Engineers, UHF Labs, Researchers interested in pTX, TOF and ASL

Purpose

The aim of this work was to develop a 7 Tesla Arterial Spin Labeling (ASL) [1,2] transceiver coil array capable of being used as a stand-alone array [3,4] or in combination with an additional transceiver head array [5]. The transceiver design is potentially beneficial at 7T since it allows for Radio Frequency (RF) transmit efficiency optimization and location-dependent B_1^+ shimming. In variation to Wiggins pioneering work [3] we utilize the same coil for transmission and reception. This allows for a mechanically smaller housing and potential for improved transmit efficiency.

Methods

The coil layout and circuitry had to support fully flexible positioning of the ASL array relative to the head array without significant coil interaction. For this a dedicated coil housing for the ASL arrays and the transceiver head coil was built utilizing Fused Deposition Modeling (FDM) (Fig. 1). The 8-channel ASL transmit array consisted of two housings each containing four 3.5 x 5.5 cm rectangular loop coils (Fig.2A); one housing would be placed on each side of the subject's neck [4]. Each of the eight unshielded ASL array coils and the 8-transceiver head stripline array was connected to a dedicated T/R switch interface located at a 25 cm distance on the patient table. This setup supported local multi-channel transmission as well as signal reception with high SNR. Geometric coil decoupling of ~14 to 18dB was achievable through optimized overlap between the loops. For the initial prototype, the 2x4 transceiver coils were realized from 14-AWG enamel coating wire with two capacitive breaks per coil loop. As the head coil we utilized 8 channels of a stripline transmission line head array [5]. Initial in-vivo acquisitions were performed on a 7T system (Siemens, Germany) using the 8-ch. ASL array only in a single subject. After obtaining B1+ maps [6], the 8 transmit phases were optimized to maximize the resulting B1+ homogeneity, calculated within a joint ROI covering both carotid arteries and tissue surrounding the arteries within ~1cm distance. Time-of-flight (TOF) images were acquired with following parameters: TR/TE = 25/2.9 ms, FA = 15 deg, 2 slabs, FOV = 130x200x80mm, 0.8 mm resolution (iso).

Results and Discussion

The design of the coil housing allowed for task presentation capabilities and flexible, yet secure mounting of the ASL arrays relative to the head array. The ASL coils had high Q_u/Q_l ratios of ~16 to 1 and achieved high SNR and low noise correlation <0.25 (Fig. 2B). Due to the lower Q of loop coils (compared to striplines), all experiments could be performed without subject specific tune and match re-adjustments, which significantly reduces setup time. The inherently perpendicular nature of the primary field components of the loop coils vs. the head array striplines enable us to achieve excellent isolation between ASL and head array >14dB regardless of coil position and without decoupling circuitry. The achievable B_1^+ transmit efficiency of the ASL array is in the order of 0.8 µT/Volt. The combined array allows for full flexibility in terms of B_1^+ shimming and parallel Transmission (pTx). To achieve optimal RF homogeneity in-vivo B1+ maps were obtained (Fig. 3). Corresponding post-shim TX efficiency was calculated to be ~80% within the carotid arteries. To demonstrate the achievable penetration depth with the 8-ch. ASL Array, TOF data was acquired as shown by native TOF images and coronal maximum intensity projection (MIP) in Fig. 4.

Conclusion

The initial experience with the ASL array / head transceiver combination is very promising in terms of transmit efficiency, penetration depth, achievable coil isolation, ease of use and ability for flexible yet secure positioning. The transceiver array concept and formfitting housing supported homogeneous and efficient spin excitation within the carotid arteries and hold strong promise for cerebrovascular investigations at 7T based on Arterial Spin Labeling of the carotids.

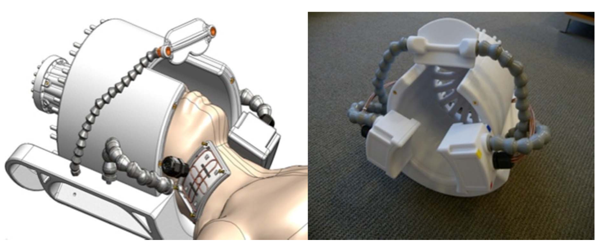

Fig.1 Shows concept and realization of the combination between a 8 ch. Transceiver Head and the 2x4 ch. ASL array.

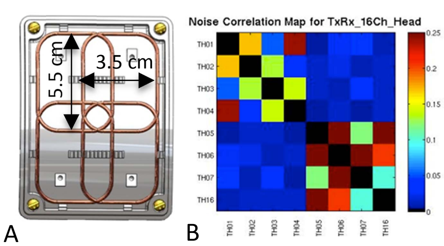

Fig.2 **A**. Schematic of the ASL coil layout **B**. Noise Correlation matrix. TH1-4 left ASL array, TH 5-7,16 right ASL array

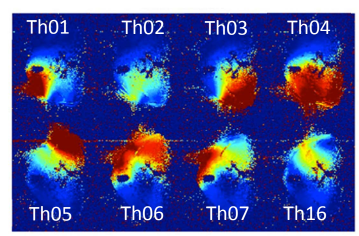

Fig.3 Relative Transmit B_1 profiles of the eight ASL arrays for a central slice.

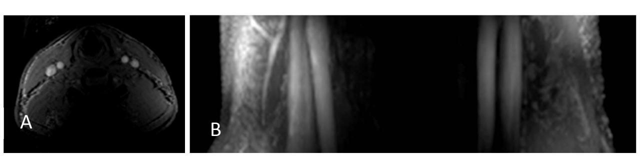

Fig. 4 A. Example of a native TOF image demonstrating penetration depth of the ASL array. **B**. 20 mm coronal MIP, 0.8mm isotropic

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