Multi-Directional MSK Phased Array Wrist Coil

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Introduction

Obtaining high resolution MRI studies of bony, ligamentous and cartilaginous structures of the wrist with phased array (PA) coils is challenging (and often uncomfortable for patients) given that wrist coils are positioned overhead or at the lateral arm causing the coils to operate near the edge of the DSV region (Fig 1(a) and (b)) where the B_0 field and the gradient fields are less homogenous as compared to the iso-center thus image quality is reduced. Here, we present a receive-only 3-element multi-directional PA wrist coil which is capable to maintain its performance even when positioned at any angle to the B_0 field. This allows positioning the coil in the center of the DSV with the possibility for relaxed overhead positioning of the wrist through "horizontal flexion" of the elbow as shown in Fig 1(c). With this setup, high image quality and patient comfort can be achieved. In the current prototype multi-directional PA wrist coil, the forearm-wrist segment can be angulated from +/-55° to B_0 offering flexible patient setup in either a prone or supine position. A prototype multi-directional PA wrist coil was constructed and successfully tested in a 1.5T Siemens Espree system (70cm bore diameter).

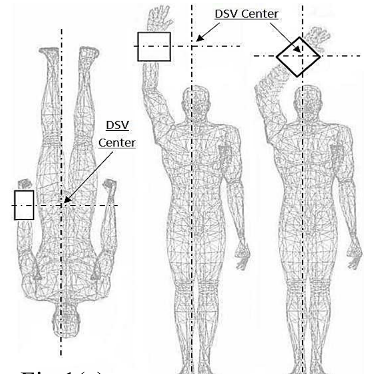

Fig 1(a) Fig 1(b) Fig 1(c)

Method

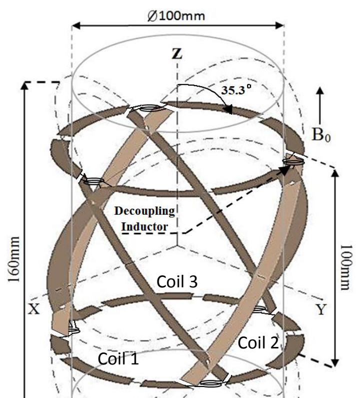

Fig 2

Shown in Fig 2 is the multi-directional wrist coil design, which uses a modified orthogonality design concept [1]. By arranging three coil elements 120° apart azimuthally and tilted to an angle of 54.7° with respect to the *XY* plane or 35.3° with respect to the *Z* axis relative to a cylindrical structure, it is shown that an inherent and constant orthogonality amongst all the individual coil elements can be achieved. This will minimize mutual coupling and allow minimal loss of efficiency and functionality even if the RF coil is oriented arbitrarily, including at 90°, relative to the B_0 field. Coil elements are designed to cover a cylindrical space of 100mm in diameter. Based on the original orthogonality concept, coil elements will cover a length of 160mm, which is unnecessarily long for wrist imaging and will hinder access of the wrist to the effective imaging space and also receive unwanted noise from adjoining forearm and hand regions thus reducing the overall SNR. Therefore, the top and bottom parts (dashed lines) of the coil element are removed so that the multi-directional wrist coil now covers a length of 100mm. However, this modification resulted in weakening the isolation power between coil elements to -8dB which is inadequate (although no apparent splitting of the resonance frequency is visible). To improve the isolation power, counter wound decoupling inductors [2] are added to the design improving the isolation power to -22dB. By achieving a high isolation power, the design does not require any low input impedance preamplifier-decoupling. This allows the use of our in-house developed, low noise 50 ohm preamplifiers for interfacing the coil to the Siemens Espree system and readily allowing the wrist coil to operate in transceive mode if desired.

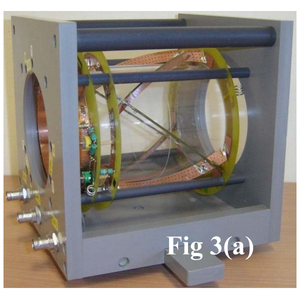

Fig 3(a)

Fig 3(b)

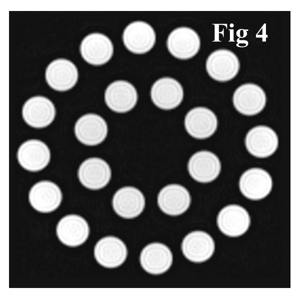

Fig 4

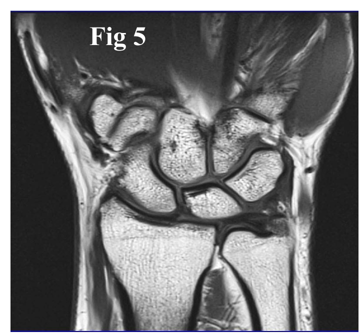

Fig 5

Results

Shown in Fig 3(a) is the picture of the constructed multi-directional PA wrist coil. The prototype is tuned and matched to 63.6MHz and in the present study used to acquire a series of proton density images of a homogenous phantom and T1-weighted wrist images (using a Turbo Spin Echo imaging sequence). These images were acquired with the multi-directional wrist coil fully angulated to 55° to B_0 and for the wrist examination the volunteer was placed comfortably in a prone-position with the arm in a relaxed overhead position and the elbow in a "horizontally flexed" posture as shown in Fig 3(b). Depicted in Fig 4 and Fig 5 are the acquired MR images of the phantom (axial image) and the right wrist (coronal image) of a healthy volunteer.

Discussions and Conclusion

In this work, a prototype multi-directional PA wrist coil for a 1.5T Siemens Espree system was successfully constructed and tested. The positioning of the multi-directional wrist coil in the center of the DSV and the possibility to angulate the coil through a wide range of angles (without degrading coil performance) demonstrate that this new PA wrist coil is capable of providing high resolution MR images of the wrist whilst enabling comfortable overhead arm positioning in patients. Successful modifications to the original orthogonality design concept were implemented for the multi-directional wrist PA coil retaining the functional integrity of the system design as evidenced by the acquired homogenous images of the phantom and the wrist (Figs 4 and 5) with the PA coil angulated at 55° relative to the B_0 field.

References [1] H Wang *et al*, An orthogonality based RF decoupling method, ISMRM, pp. 3926, 2010. [2] E Weber *et al*, A Novel 8-Channel Transceive Volume-Array for a 9.4T Animal Scanner, ISMRM, pp. 151, 2008.