A novel multichannel wireless receive phased array coil without integrated preamplifiers for high field MR imaging applications

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Introduction: Since the introduction of phased array technology and particularly the introduction of massive number of receive arrays that assist in faster image acquisitions using parallel imaging, the need for reducing or eliminating the size of the RF cables has been apparent. Long cables for coils with large number of channels (abdomen and lower extremities coils) create significant weight and bulkiness. Additionally, cable traps are required to avoid RF heating which introduce complexities and weight to the structure. Over the past few years, there has been numerous attempts to reduce or eliminate the need for RF cables by different techniques such as active wireless, fiber optic driven or cable-less coils [1,2,3,4]. Each of these techniques has its challenges. The recently introduced wireless coil [1] requires constant power for operation which adds additional components to the coil/system and creates heating. Furthermore, use of the wireless technology results in degradation of image quality and SNR for phased array coils compared with their cabled counterpart. Other proposed solutions use fiber optics [2] for signal transmission. This technique has the advantage of significant reduction in the number of RF cable lines and hence the reduction in weight of the entire cable assembly. However, this method requires fiber to RF conversion which makes the coil bulky compared with conventional coils and introduces heating. Additionally, the presence of DC power lines requires use of cable traps which add complications to the coils. Early attempts at inductive coils [3,4] used a local coil to communicate between the single channel inductive coil and the system. No phased arrays were considered in these designs.
In this paper we present a novel wireless receive phased array design that is remotely positioned on the imaging region and, inductively coupled to the body coil [5]. The body coil is used for transmit and receive. The proposed coils have no pre-amplifiers or active elements (active detuning circuits) and require no cables. This leads to reduction in weight and bulkiness of the coils without significantly sacrificing image quality and SNR. Additionally, due to removal of the coil IDs, coils can operate with any OEM MR system at the particular field of interest. The presented results show equivalent image quality and performance compared with a 12 channel commercial phased array coil.

Methods: The proposed lower half wireless phased array design dedicated for head imaging is shown in figure 1. A total number of three channels are geometrically decoupled with isolation up to -25 dB. FR4 laminate with copper trace of width 10mm was used with individual upper and lower coil dimensions of 280 x 200 mm. An additional wireless single channel butterfly coil was designed for the upper half with similar outer dimensions. The coils were tuned to 63.65 MHz to be used with 1.5T Siemens Espree MR System. Passive decoupling network and RF fuse is used for each element of the coil. Measured unloaded quality factors on order 300 were measured on the bench. No matching network is required due to the lack of active pre-amplifiers.

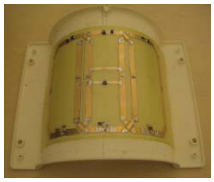
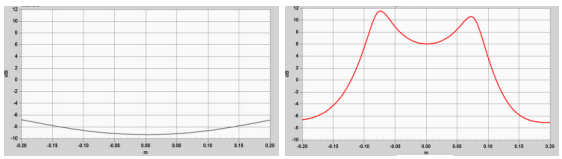


Fig. 1 Wireless Array

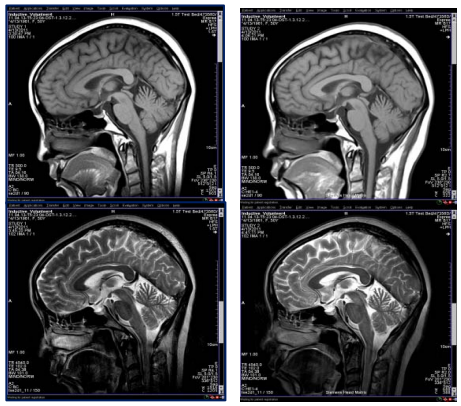
Results: 3D full wave analysis simulation (FDTD) of the single channel wireless inductive coil combined with the 1.5T body coil shows an increase of more than 15dB in B1 field sensitivity in the region of interest compared with the baseline (body coil only) as depicted in Fig. 2. SNR of 98 and 102 was measured using Siemens 7300 ml bottle phantom for the wireless phased array coil and the 12 channel commercial head coil respectively. Upon completion of all the safety tests, volunteer head images were obtained using standard T1, T2 sequence. The obtained head images for the wireless inductive coil and the 12-channel commercial head coil are depicted in Fig. 3(a) and 3(b) respectively. As seen from volunteer images both in terms of SNR as well as image quality, no noticeable degradation using the four channel wireless coil is visible compared with the 12-channel coil. The wireless phased array coil exhibits good image quality and coverage



(a (b

Fig 2. B1 sensitivity vs. distance (a) Body coil (b) Body coil &wireless

Conclusion: A novel wireless phased array coil that is inductively coupled with the body coil is presented. This coil design eliminates the use of cables and all active components (such as pre-amps and active diodes). This design reduces the overall dimensions of the coils as well as drastically improves the workflow during imaging. Additionally, B1 field sensitivity was improved by 15 dB. SNR and volunteer imaging indicate that the proposed design demonstrate equal performance compared with available 12-channel head coils. Finally, the lack of coil ID requirement enables the coils to work on any OEM MR system at the particular field.



(a) (b)

Fig 3 Volunteer head images (a) Inductive wireless coil (b) 12-channel commercial coil

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