Stretchable coil arrays

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Introduction: The number of receiver coils typically used in MRI has significantly increased over the past few years. Therewith issues like coil handling and optimal coil arrangement for optimal SNR, i.e. placing the coils as close as possible to the imaging object, as well as patient comfort must be addressed. Achieving an optimal coil arrangement is difficult due to the varying size of the imaging object but can be done by using coil arrays that permit mechanical adjustment [1]. However this approach is ultimately limited because mechanical adjustments are only possible in a certain range. The ultimate solution is using stretchable coils that automatically adjust their size to the object thus providing the optimal coil arrangement in terms of SNR. The key problem in realizing such a coil is a stretchable conductors and the change in resonance frequency due to the stretching of the coil array must be addressed. Here we present the first stretchable 8-channel coil array and show results in-vivo measurements of different sized wrists.

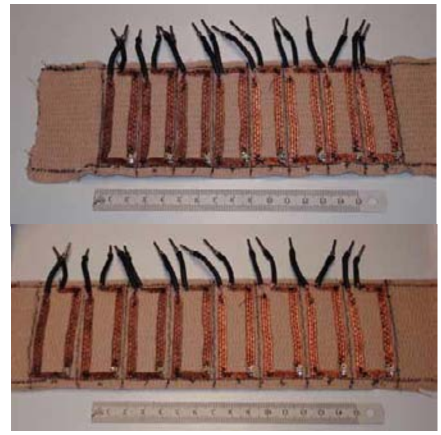

Fig. 1: 8-channel coil array relaxed (top) and stretched (bottom). The top fabric layer is removed to show the single coil elements. While stretched the size of the individual coil elements increases.

Materials and Methods: The stretchable 8-channel coil array (Fig. 1) is made of an elastic fabric support consisting of cotton and polyamide and 5-mm-wide copper braid for the coil elements. The braid combines high flexibility and stretchability as well as conductivity comparable to that of solid copper strips. From unloaded Q measurements the resistance of a single coil element was calculated to be $R = 0.8\ \Omega$. The copper braid is sewn to the fabric and covered by a second layer of fabric to avoid direct contact with the copper elements. The coil elements are connected to a preamplifier (Fig. 2) through a π matching network and coupling between elements is suppressed by preamplifier decoupling [2]. The combination of coil and resonant matching network gives a frequency response with two peaks and a flat region in the middle thus slight changes in the inductance of the coil can be tolerated. All measurements were performed on a 3T Achieva system (Philips Medical Systems, Best, The Netherlands). The coil is connected to the scanner through a multi-channel connector box [3]. Two different sized truncated conical phantoms were imaged (diameters: 78/59 mm and 65/46 mm respectively, filled with copper sulfate solution) using an FFE sequence. Between the measurements the tuning and matching configuration of the coils and preamplifier boards was not changed. With the same setup the different sized wrists of two volunteers were measured using an FFE sequence (FOV 72x72 mm^2, acq. Matrix 352x352, rec. matrix 512x512, TE=5.6 ms, TR=97.2 ms, 10 averages). Both volunteers reported a significant increase in comfort due to the smoothly adjusted coil array.

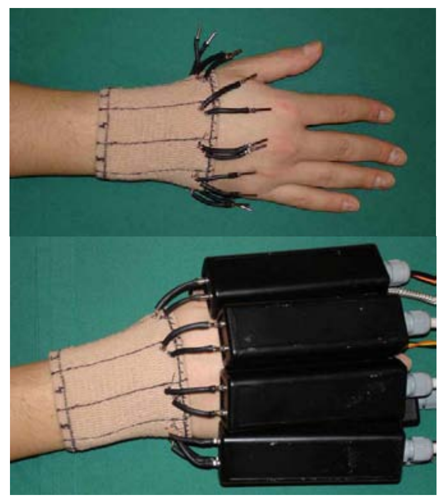

Fig. 2: Stretchable 8-channel coil array wrapped around the wrist and smoothly accommodated to it (top). The black boxes contain the preamplifiers (bottom).

Results: Consistently good SNR was achieved in the phantom measurements, with only a slight SNR drawback notably in the center of the larger object, which is to be expected from simple scaling considerations. For the large phantom the coil was stretched by 20% whereas for the small one the coil array was almost completely relaxed. Images did not suffer from excessive coupling or transmit B_1 distortion. Figure 3 shows high-resolution in vivo images of the different-sized wrists of two volunteers. These images, too, show excellent SNR and also no major difference related to the change in coil size and tuning, again except for a slight SNR benefit with the smaller anatomy.

Discussion: We have demonstrated a successful implementation of a stretchable coil array that provides consistent performance across different-sized objects. Wrist imaging confirmed the practical feasibility and increased patient comfort of the stretchable-coil approach. Despite different amounts of stretching the SNR performance was not critically degraded by the resulting changes in tuning and matching. This is due to the flat frequency response that tolerates slight changes in coil inductance. Notwithstanding the influence of varying impedance of the coil on the gain and noise figure of the preamplifier needs to be further investigated. Further technical development shall focus on means of automatic impedance compensation, miniaturization of the preamplifier electronics, and improvement of the stretchable conductor.

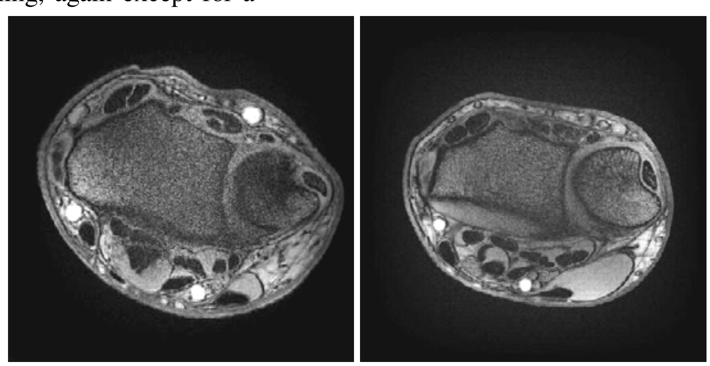

Fig. 3: Images of two different sized wrists of two volunteers using the same field-of-view of 72 x 72mm². The in-plane resolution is 205x205 μm².

References: 1. Massner J et al., Proc. ISMRM, p. 416 (2006) 2. Roemer PB, MRM 16, p. 192 (1990) 3. De Zanche N et al., Proc. ISMRM, p. 2030 (2006)