Stretchable coil arrays enable knee imaging at varying flexion angles

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Introduction The number of receiver channels and coil array elements used in MRI has significantly increased over the past few years, raising practical issues such as the handling and placement of large numbers of coil elements. Bringing all surface coils close to the imaging region is necessary for optimizing the imaging performance, while patient comfort and ease of handling are also essential. All of these objectives suggest that coil arrays should become more geometrically flexible than today's mostly rigid array designs. One way of achieving greater flexibility is by mechanical adjustments of semi-rigid arrays [1,2]. However, arguably the ultimate in flexibility could be accomplished with coil elements that are themselves stretchable and thus automatically adapt to the individual anatomy's size and shape. When used for the imaging of joints this approach uniquely allows measurements at different flexion angles without rearranging the coils. To explore these opportunities, in this work we present a first stretchable 8-channel array for knee imaging.

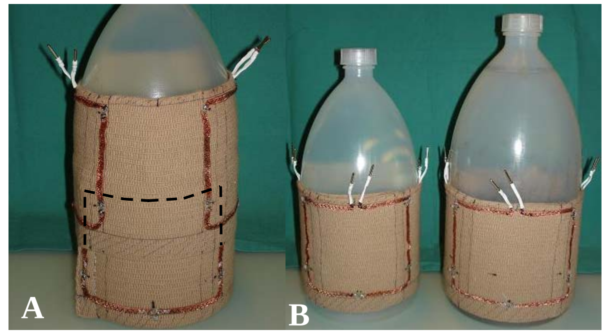

Fig. 1: (A) Open view of the two rings building one half of the coil array showing the overlapping coil elements. (B) The two four-element halves of the coil array around different sized phantoms (Circumference 35 cm and 44 cm).

Materials and Methods The initial challenge of building stretchable coils is identifying a suitable conductor. We used 5 mm wide copper braid which combines flexibility and stretchability with high conductivity comparable to that of a solid copper strip. The copper braid is sewn to stretchable fabric made of cotton and polyamide. Overlapped coil elements were used for approximate geometric decoupling. Residual coupling was suppressed by preamplifier decoupling [3] similarly to ref. [4]. The array consists of four rings of fabric with two coil elements each at diametrically opposite locations. Pairs of such rings were overlapped with a rotation of 90° to form a ring of four overlapping elements (Fig. 1A). The circumference in the relaxed state is 340 mm and can be stretched to about 440 mm to accommodate various knee sizes (Fig. 1B). The two four-element rings are arranged with an axial overlap of 20 mm, leading to a FOV of approximately 170 mm along the length of the leg (Fig 2). The coils are connected through a multi-channel interface box [5] to a 3T Philips Achieva system (Philips Medical Systems, Best, The Netherlands). Imaging was performed on a healthy volunteer using a gradient echo sequence in transverse (TE 4.9 ms, TR 77 ms, FOV 140 mm) and sagittal (TE 4.1 ms, TR 63 ms, FOV 200 mm) orientations with a slice thickness of 5 mm, acq. matrix 512×410, 8 averages. The in-plane resolution was $270 \times 340\ \mu m^2$ for the transverse and $390 \times 490\ \mu m^2$ for the sagittal images. Sagittal images were taken consecutively at two different flexion angles of the knee without any adjustments to the coil array.

Fig. 2: 8-channel stretchable knee coil accommodated to the knee without (top) and with (bottom) preamplifier modules.

Results Figure 3 shows a transverse slice of the knee the level of the patella and two sagittal slices, one with the knee extended and one with the knee flexed. These data confirm both a high overall SNR yield and robust homogeneous coverage even with major changes in the coils' stretching state and relative position. Coupling artifacts or transmit B_1 distortions are not observed, indicating robust preamplifier decoupling and detuning performance.

Fig. 3: Transverse and sagittal images of the knee of a healthy volunteer. The in-plane resolution is $270 \times 340\ \mu m^2$ for the transverse and $390 \times 490\ \mu m^2$ for the sagittal images.

Discussion A first implementation of a truly stretchable knee array has been presented. The array accommodates to the individual size and shape of the patient's anatomy, combining high imaging performance with ease of handling and patient comfort. The new array concept is ideally suited to enable imaging the knee at different flexion angles in immediate succession, which is not possible with present-day commercial knee coils. In combination with fast sequences highly-sensitive dynamic imaging of the knee joint is a promising perspective. Finally, patients may appreciate the fact that a stretchable coil array is worn essentially like a normal piece of clothing or an elastic bandage.

References [1] Massner et al., Proc. ISMRM, p. 416 (2006) [2] Adriany et al., Proc. ISMRM, p.673 (2005) [3] Roemer et al., MRM 16, p. 192 (1990) [4] Massner et al., Proc. ISMRM, p. 1051 (2007), [5] De Zanche et al., NMR in Biomedicine, in press (2007).