A multi-purpose flexible antenna for musculoskeletal MR imaging at 3T

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Target audience: MR physicists and technologists, musculoskeletal radiologists.

Purpose:

Flexible coils and antennas have attracted much attention recently because they can highly improve patient comfort and achieve geometrical flexibility to image joint tissues under different flexion angles. Many flexible coils have been proposed for imaging different joint tissues, such as knee[1] and wrist[2]. But they can only be used for imaging of one particular joint tissue, there is a strong demand to develop a new flexible coil to cover more regions of the musculoskeletal system. In this study, we proposed a Multi-purpose Flexible Flex Cable Antenna (MFFCA) for imaging of hand and wrist, shoulder, elbow, ankle and knee, which has the advantages of high flexibility, satisfied comfort, large FOV, high SNR and low cost.

Materials and Methods:

Inspired by the loopless monopole antenna[3], we designed the MFFCA which has a flex cable (80 cm in length), a tuning/matching circuit and a signal transmission line (Figure 1). The MFFCA is only employed to receive signal while the body coil is used for exciting. The flex cable has 60 elements. Each element has the diameter of 0.6 mm and the distance between two adjacent elements is 1.0 mm. The tuning and matching circuit consists of 3 tunable capacitors (C_1, C_2, and C3) and a fixed capacitor (C_4). The antenna is connected to a 3T whole-body MRI system (Signa™, GE Medical Systems) through a signal transmission line.

In order to evaluate the feasibility and validity of the proposed MFFCA, the musculoskeletal system of a health volunteer (age 25, male) was examined by using the MFFCA. For imaging of shoulder, ankle and knee, the volunteer was asked to lie down in supine position and the MFFCA was put on the top of the targeted joint tissues by sticking medical plastic tape. For imaging of elbow, the volunteer was required to lie on his stomach with the palm of the hand up and the MFFCA was placed on the top of the arm by sticking medical plastic tape while the arm was in the opposite direction for imaging of hand and wrist. To better demonstrate the high flexibility of our design, we carried out the imaging experiments of elbow, ankle and knee under different flexion angles with the aid of foam blocks and a homemade supporting gadget. The scanning parameters were: sequence: FSE (T1WI: repetition time (TR)=400.0 ms, echo time (TE)=12.4 ms; T2WI: TR=3000.0 ms, TE=102.0 ms; PDWI: TR=3000.0 ms, TE=12.4 ms), slice thickness=6.0 mm (shoulder, hand and wrist, elbow, ankle) or 7.0mm (knee), slice spacing=0 mm, Matrix=256×256, and NEX=4.0 (shoulder, hand and wrist) or 2.0 (elbow, ankle, knee). The coronal, sagittal and axial images were acquired for shoulder, hand and wrist while the sagittal images under different flexion angles were obtained for elbow, ankle and knee. To evaluate the safety of the MFFCA, we utilized the optical fiber thermometer to measure the temperatures of the surface of flex cable under three different positions during the scan of two continuous sequences (3min48second) and the probes were placed between the tissues around the knee and the flex cable.

Results:

As shown in the images of shoulder, hand and wrist, fine anatomic details are rendered and different joints and tissues show clear contrast. The magnetic field distribution of the MFFCA is homogeneous and the SNR of the image is high enough for clinical applications. The images of elbow, ankle and knee under different flexion angles also demonstrate clear contrast between different joints and tissues, high SNR and satisfied homogeneity. Besides, the knee images suggest that the longitudinal coverage of the MFFCA can achieve more than 48 cm, which is much larger than conventional surface coils, birdcage coils and array coils. The largest temperature increment of the three positions during the scan is 1.4℃, which proves the safety of the MFFCA.

Discussion & Conclusion:

The results have demonstrated the high flexibility, large FOV, high SNR and safety of the MFFCA. The flex cable is lightweight and can be placed close to the tissues for higher SNR. Actually, the MFFCA is very suitable for joint imaging with different flexion angles under dynamic situations to evaluate joint abnormalities which exhibit physiological changes only under dynamic conditions, such as neuro-muscular contractures and joint malformations[4]. In the future, we will carry out the real-time MR imaging of joint movement using the MFFCA.

In conclusion, we developed a multi-purpose flexible antenna for musculoskeletal MR imaging with high flexibility, satisfied comfort, large FOV, high SNR and low cost, which can be applied in the assessment of musculoskeletal tissues, especially under flexion and dynamic conditions.

References:

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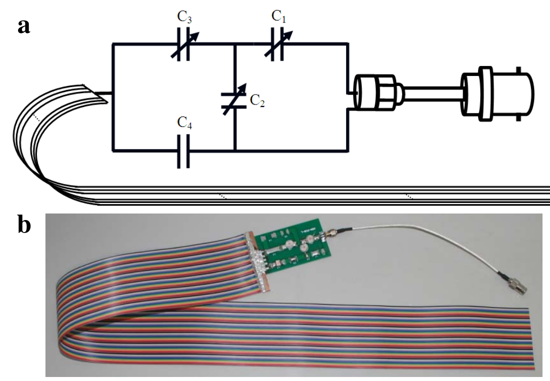

Fig 1. The schematic diagram (a) and photo (b) of the proposed MFFCA.

Fig 2. The MR images of musculoskeletal tissues at different body parts by using the MFFCA (A. hand and wrist (T1WI, FOV: 28×28cm), B. shoulder (T2WI, FOV: 24×24cm), C. elbow (PDWI-Sag, FOV: 32×32cm), D. ankle (T2WI-Sag, FOV: 30×30cm), E. knee (PDWI-Sag, FOV: 48×48cm)).