Open Phased Array Knee Coil for Dynamic MSK MRI

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Introduction

Current commercially available MRI phased array (PA) knee coils are designed as a closed structure composed of fixed coil elements fully enclosing the knee joint. As a result, closed PA knee coils can only allow assessment of knee injuries and pathology under static conditions with the knee in an extended position rather than allow dynamic MR imaging across a wide range of joint flexion angles. Here, we present a receive-only 3-element open PA knee coil which we have designed and constructed to allow dynamic imaging of the knee joint under various degrees of flexion to facilitate diagnostic and functional assessment of knee injuries and pathology. The prototype open PA knee coil was successfully tested in a 1.5T Siemens Espree system (70cm bore diameter). The acquired MR images of the knee joint, flexed to a variety of angles and also at the normal relaxed position, show that the open design concept is feasible for dynamic musculoskeletal (MSK) MR imaging of the knee.

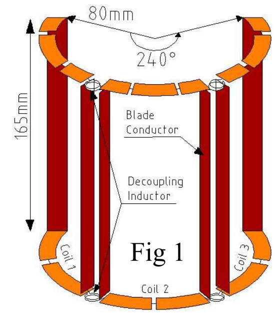

Fig 1

Method

Fig 1(a) shows the design of the 3-element open PA knee coil. The coil elements are designed to cover a circular arc space (covering the knee joint and the anteriorly located patella) measuring 80mm in radius spanned around a central angle of 224° and 165mm in length. Each rectangular coil element has a size of approximately 98mm in width and 165mm in length, with a separation distance between coil elements of 5mm. For dynamic MSK MRI, the flexion of the knee joint will subject the open PA knee coil to variable loading effects, causing the open PA knee coil to become mismatched and/or detuned. To subdue these adverse changes, coil elements are designed using blade conductors [1], which have the edge of the conductors facing the load. This reduces the coil-load capacitive coupling effect thus ameliorating mismatching and/or detuning. In addition, the use of blade conductors effectively enlarges the aperture size of each coil element. This in turn increases the RF field penetration and allows regions outside the arc space to be imaged as well. To handle mutual decoupling between coil elements, counter wound decoupling inductors [2] are implemented and isolation power of -22dB between coil elements under loaded condition can be obtained. With such 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 MRI system, which simplify the construction process and allows the knee coil to operate in transceive mode if desired.

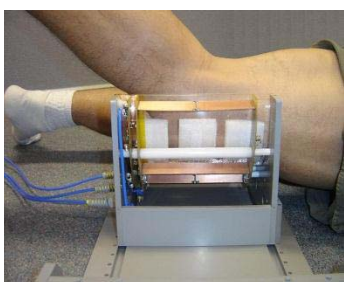

Fig 2

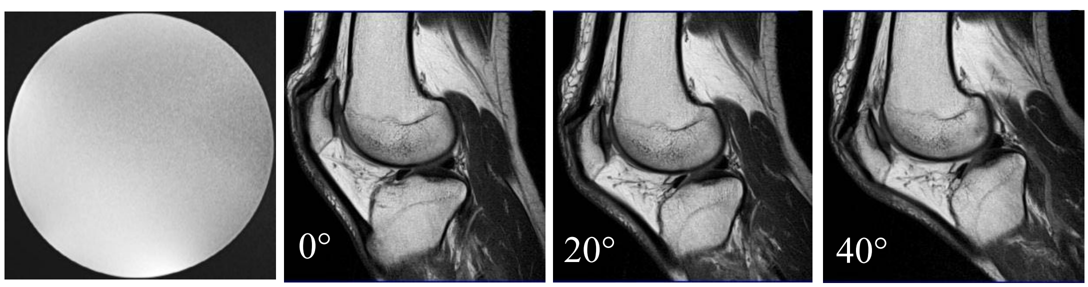

Fig 3(a) Fig 3(b) Fig 3(c) Fig 3(d)

Results

Shown in Fig 2 is the picture of the constructed open PA knee coil loaded with the knee, flexed to 40°, of a volunteer. Note that during the MRI experiments, the volunteer is in a prone-position with the patella facing inwards toward the circular arc space and the open top space allows flexion of the knee joint. The prototype is tuned and matched to 63.6MHz once (no further tuning and matching are performed) and in the present study used to acquire a static series of proton density images (using a Turbo Spin Echo imaging sequence) of a homogenous phantom and the knee joint in the extended positioned (0°) and flexed to 20° and 40°. Shown in Fig 3(a) is the MR image of the phantom and Figs 3(b) to (d) are images of the knee joint at different flexion angles. These knee joint images demonstrate the progressive inferior tracking of the patella with respect to the femur during increased flexion.

Discussions and Conclusion

In this work, a prototype open PA knee coil for a 1.5T Siemens Espree system has been successfully constructed and tested. The acquired knee images of Figs 3(b) to (d) show that the open concept design is feasible and well suited for dynamic MSK MRI examinations. The use of blade conductors for constructing the coil elements reduced the sensitivity to load changes and also created more space to enlarge the aperture size of all coil elements. This increased the RF field penetration and thus allowed regions of the sample located partially outside the arc space to be acquired, as shown by the phantom image of Fig 3(a).

References

[1] E Weber *et al*, A Novel 8-Channel Transceive Volume-Array for a 9.4T Animal Scanner, ISMRM, pp. 151, 2008.
[2] S Crozier *et al*, Coil decoupling. US 20100182009, 2010