A 16-Element Highly Flexible RF Array Coil for 3T MRI

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Introduction

Array coils have gained a prominent role in MRI because of their capability of providing high SNR over a broad field of view (FOV) as well as accelerating image acquisition.[1-3] The SNR of array coils depend on the filling factor of the coils because the sensitivity of each coil element dramatically attenuates with the increase of the separation between the coil element and the object to be imaged. A desirable array coil therefore is expected to be positioned closest to the object. This requires that the array coil must be highly flexible in order to fit for objects of variable dimensions and the coil built in a way that its flexibility does not affect its performance. Although some adjustable array coils have been proposed,[4-5] their flexibility is limited because of the extreme difficulty in decoupling between coil elements with the change of coil geometries.[6] We present a 16-element array coil with high flexibility and provide a comparison study between the highly flexible array coil and a rigid cylindrical coil based on our research on high decoupling.

Materials and Methods

Our coil was consisted of 16 loop-elements formed by 5mm-wide copper strips. Each element was a loop of 220mm in length and 60 mm in width with 6 capacitors distributed uniformly around the loop: C_1-C_4, C_t and C_m (Figure 1a). The loop-elements were attached to a flexible plastic sheet (Figure 1b, 1c). The adjacent elements were overlapped by about 10% in area for initial decoupling. Each loop was matched to 400 ohms and connected to a low-impedance preamplifier for high decoupling.[7] Each coil element was detuned during RF transmission by a RF trap formed by the a capacitor (C_4), an inductor (L) and a PIN-diode (D) biased by the MRI scanner. The coil can be used to directly wrap over the object to be imaged, allowing the closest proximity between the coil and the object and, consequently, the optimal sensitivity of the coil. For comparison, we also constructed a 16-ch array coil on a rigid acrylic cylinder former (figure 1d). The coil had a 250mm diameter and 220mm length. The coil elements had similar layouts with that of the flexible array coil with minor adjustments to uniformly fit on the cylinder former.

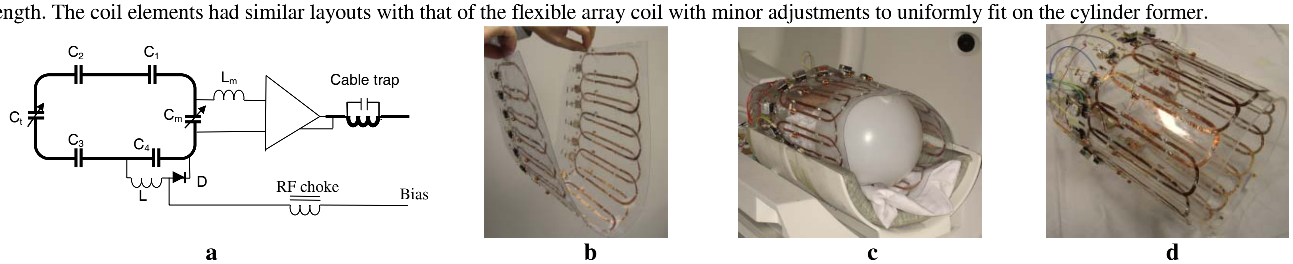

Figure 1. a:the schematic circuit of a coil element; b: the flexible coil under construction; c: the finished felxible coil with the phantom on the cradle; d: the rigid array coil

We acquired images from a spherical phantom with a diameter of 180mm on a GE Signa HDx 3 Tesla MRI scanner using a spin echo sequence: TR/TE/flip angle=2000ms/8ms/90°, FOV=260mm, matrix=256×256, slice Thickness=3mm, and bandwidth=15.63kHz. In order to compare the performance of the individual coil elements as well as the entire array coils, we separately acquired the images using the single elements and the array coil for both coils.

Results and Discussion

The decoupling between coil elements of the array coils were measured to be -37dB and better. This high decoupling was also confirmed by the distinct sensitivity profiles of individual coil elements through the images from the individual coil elements of both flexible array coil and rigid array coil (Figure 2a, 2b). Images from the individual elements of the flexible coil had the highest SNR of 1932 at the periphery close to the coil element, compared to the SNR of 1026 of the image from the single elements of the rigid coil, indicating that the SNR of images from the individual coil elements was improved by 88.3% by positioning the coil elements closest to the phantom using the flexible coil (Figure 2c). When the images from all coil elements were combined, the SNRs of image from the flexible coil were measured to be 1342 at the periphery and 678 in the center (Figure 2d, 2f), while the SNRs of image from the rigid coil were measured to be 667 at the periphery and 218 in the center (Figure 2e, 2f). Thus, the SNR of the combined images was improved by more than 100% by using the flexible array coil compared with the rigid array coil. Beyond, the ratio of the lowest SNR (periphery) to the highest SNR (center) of the images from the flexible coil was 50.5%, compared to 32.7% of the rigid coil. Thus, in addition to higher SNR, the flexible coil provided higher image homogeneity than the rigid coil as well.

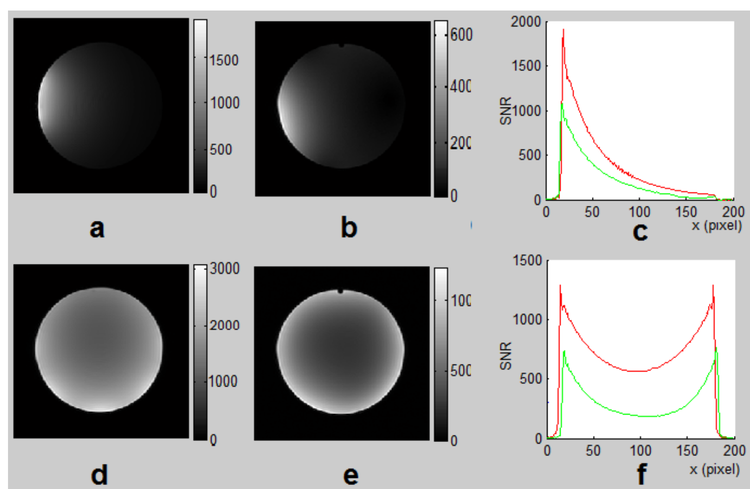

Figure 2. Images from individual coil elements of the flexible array coil (a) and the rigid array coil (b) and their SNR distributions along the horizontal line across the center of the image a (c: red) and image b (c: green), along with the combined images from the flexible coil (d) and the rigid coil (e) as well as the corresponding SNR distributions of image d (f: red) and image e (f: green).

Conclusions

The decoupling of highly flexible array coils is extremely challenging. However, properly decoupled flexible array coils are able to significantly improve the SNR and homogeneity of images. Our research also showed that flexible coils could be more sensitive to motion artifacts than rigid coils. This will be addressed in detail in our further research report.

References

1. Romer PB, et al. The NMR phased array. Magn. Reson. Med.. 1990. 16(20):192-225.
2. Wright SM, et al. Theory and application of array coils in MR spectroscopy .NMR Biomed. 1997. (10) :394-410.
3. Fujita H. New horizons in MR technology: RF coil designs and trends. Magn. Reson. Med. Sci. 2007; (6): 29–42.
4. Keil B, et al. Size-optimized 32-channel brain arrays for pediatric imaging. Magn. Reson. Med.. 2011. 66:1777-1787
5. Adriany G, Moortele et al. A geometrically adjustable 16-Channel transmit/receive transmission line array for improved RF efficiency and parallel imaging performance at 7 Tesla. Magn. Reson. Med. 2008. 59: 590-597
6. Lee RF, et al. Coupling and decoupling theory and its application to the MRI phased array. Magn. Reson. Med. 2002. 48: 203-213
7. Duan Y, et al. System, arrangement and method for decoupling FR coils using one or more non-standardly-matched coil elements. US patent: 231175.US.01-486328100 (attoney docket number)