A 19F/1H dual resonant 7T elliptic body coil that double tuned by ellipticity

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INTRODUCTION

19F-MRS has potential to be used for studying gemcitabine metabolism in patients with adenocarcinoma of the pancreas. To take advantage of high SNR at 7T, a 19F/1H double tuned 7T elliptic body coil was designed and constructed. The novelty of this coil is that the ellipticity is used as the double tuning mechanism to achieve homogeneous excitation at both 1H and 19F resonance frequencies, which deviates from the traditional elliptic coil whose goal is to improve the efficiency of the coil (1-3). Obviously for a 7T body coil, the additional benefit of efficiency improvement is also a vital factor.

METHOD

1. Ellipticity for double tuning

For a given mode, a circular structure only allows one standing wave exist which corresponds to a single resonance frequency. However, an elliptic structure allows two standing waves co-exist which corresponding to a double resonance for the same mode, in this case, the homogeneous mode. To analytically describe this double resonance phenomenon, an ellipse in Cartesian coordinate is conformal mapped to Elliptic coordinate in which the ellipse becomes a circle. Its angular measures are θ and ϕ in Cartesian coordinate and Elliptic coordinate, which has relation

$$\theta = \tan^{-1}(\frac{n}{m})\tan(\phi)\cdot \qquad [1]$$

Here *m* and *n* are major and minor axes. The angular frequency relation between Cartesian and Elliptic coordinate can be derived from Eq. [1] as

$$\frac{d\theta}{dt} = \frac{1}{1+(\frac{n}{m}\tan\phi)^2}\frac{n/m}{\cos\phi^2}\frac{d\phi}{dt} \qquad [2]$$

In Elliptic coordinate, since the ellipse becomes a circle, its angular frequency (dϕ/dt) is unique for a given mode. But its angular frequency in Cartesian coordinate is not unique and also depends on the angle ϕ. From Eq. [2],

$$\text{If } \phi=0,\quad \frac{d\theta}{dt} = \frac{d\phi}{dt};\quad \text{and if } \phi=90°,\quad \frac{d\theta}{dt} = \frac{n}{m}\frac{d\phi}{dt} \qquad [3]$$

So the ratio of minor to major axes is the ratio of two double tuned frequencies. In the case of 19F/1H double tuning, if *n/m*=0.94 and the rungs are distributed in equally angular spacing, double tuning can be achieved.

2. Elliptic coil for both double tuning and improving coil efficiency

For a typical human torso, the better ratio of *n/m* is 0.78 not 0.94. Theoretically both goals can be achieved by re-arranging the spacing of the rungs. In stead of using 0.77 in Eq. [1] for compensating the ellipticity or using equal angular spacing for double tuning only, one can use the ratio 0.77/0.94 to substitute ratio *n/m* in Eq. [1]. In experiments, this can provide the first-order estimation for the rungs position.

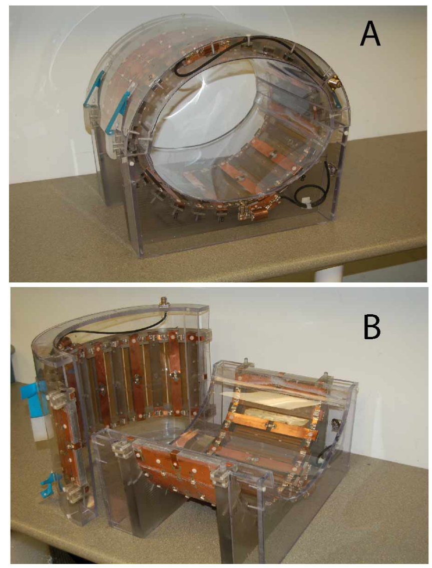

Fig 1

EXPERIMENTS

A 12 rungs elliptic shielded high pass birdcage was built for Siemens 7T whole body MR scanner, see Fig. 1. Its major and minor axes are 41.9cm and 32.7cm, the ratio of *n/m*=0.78.The angular location of the rungs are: 20.6°, 49.5°, 81.2°, 114.3°, 144.8°, 173.3°, 200.8°, 230°, 262.1°, 295°, 325.3°, and 353.3°. The coil is consist of two half birdcages. When they electrically connected together, it is tuned to 297.2 MHz (1H) and 279MHz (19F) at two ports 90° apart.

A 1H image of large turkey was acquired using this coil with 0.3mmx0.5mmx2mm resolution, as shown in Fig. 2. The pulse sequence used for this scan is a 3D FLASH, TR=23ms and TE=3.8ms. The data acquisition matrix is 1024x786. Note that some dark band artifacts may be caused by the shimming issue. The 19F MRS will be tested when our scanner is equipped with multi-nucleus capability by the end of this year.

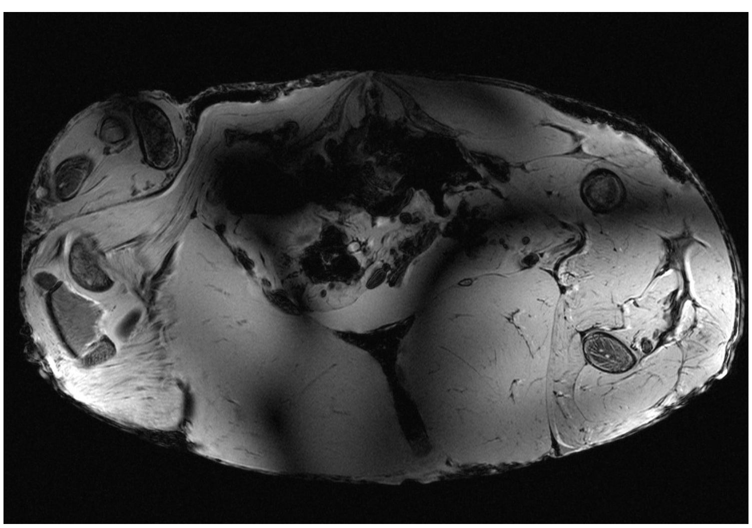

Fig. 2

CONCLUSIONS

We have analytically and experimentally proved that ellipticity can be used for 7T 19F/1H double tuning body applications. Such ellipticity also can significantly improve the coil efficiency which is currently a major issue in 7T body imaging.

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