Inductively Coupled Birdcage Coil

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INTRODUCTION

In MRI, internal coils, which are designed for diagnostic and interventional procedures, increase the signal-to-noise ratio of the images significantly when compared to conventional imaging coils. This is because, these coils can be placed near a region of interest (1,2). They, however, are connected to scanner hardware by cables, which bring safety and handling problems. In addition, each of these coils is imager and site dependent because of special hardware and software requirements.
Although birdcage coils are essential elements of modern MRI scanners, they have never been miniaturized for placement inside body orifices such as the rectum and used as inductively coupled coil elements. In this study, inductively coupled birdcage coil (ICBC) and receive coupled birdcage coil (RCBC) (3) are introduced as internal coil. These coils can be used without modifying the scanner hardware and do not affect tuning of external coils. ICBC coils are not connected to the scanner by wires; rather the MR signal picked up by these coils is transferred to a receiving coil by induction. Therefore, they are system independent.

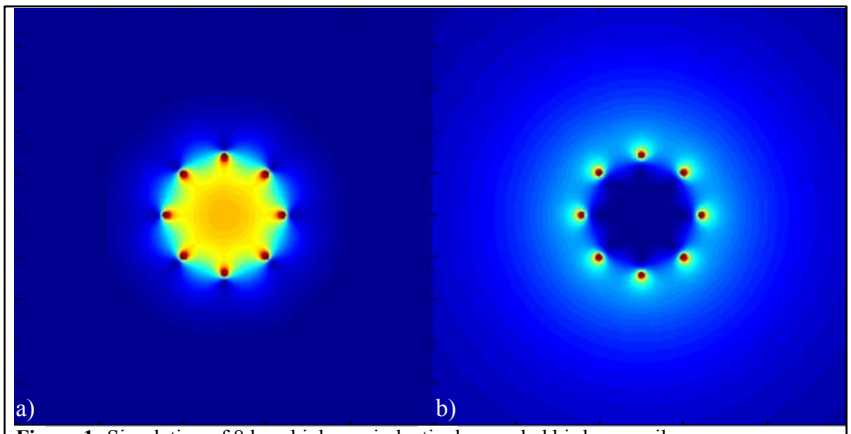

Figure 1: Simulation of 8 legs highpass inductively coupled birdcage coils.
a) Forward mode of ICBC b) Reverse mode of ICBC

THEORY

Quadrature birdcage volume coils are designed such that they create uniform forward polarized magnetic field inside the coil. If one reverses the coil in z-axis, the signal inside the coil becomes reverse polarized. New birdcage coil design is used inductively. There is no feed point for transmission, reception, or decoupling. In addition, it is symmetric with respect to all axes. They are small and do not affect the tuning and noise profile of the external coil. Furthermore, coupled birdcage designs are immune to orientation, i.e. it can work in all orientations. The signal inside and outside the inductive designs depend solely upon the mode of the external coil. Coupled birdcage coils produce forward polarized field inside the coil. On the other hand, the outside of the coil is the source of the reverse polarized signal (**Error! Reference source not found.**1).
Since ICBC coils have two intrinsic orthogonal modes of operation, the transverse component of the magnetic field (sensitivity) exists in all orientations. For example, if the axis of the ICBC coil is directed to the x-axis (as opposed to the z-axis in its optimum use), one of the modes will be in the y-axis. Therefore the coil's sensitivity will remain.

METHOD

Coupled birdcage coils were constructed 2.5 cm long and their diameters are 2.5 cm. Pairs of back-to-back diodes have been used to build receive only birdcage coil (RCBC) in order to decouple them from transmit field for better safety profile (3). In addition, 2.5 cm long and 2.5 cm wide loop coil has been built to compare coupled birdcage coils.
Small birdcage coils have been examined with Siemens TIMTrio with a transmit array system. Receive-only external birdcage coil has been used to examine inductively coupled coils. Using transmit array system paved the way of taking advantage of all transmit/receive combinations of the receive-only external coils: a) forward transmit and receive, b) forward transmit, reverse receive, c) reverse transmit and receive, d) reverse transmit and forward receive. A gradient echo sequence with following parameters is used: TR 20 ms, TE 10 ms, slice thickness 2 mm, flip angle 30^0, FOV 250X250, imaging matrix 256X256,

RESULTS

Due to the coupling nature of the small birdcage coils, external coil characteristics directly affect coupled birdcage coils. In order to observe the response of small coils to transmit and receive polarizations, the forward and reverse polarization combinations of transmit and receive coils are examined.
When transmit and receive fields are forward, which is the normal working type, the anatomy signal intensity is maximum (Figure 2b). On the other hand, when both transmit and receive coils are reverse polarized, the anatomy signal becomes minimum and the reverse polarized signal is maximum (Figure 2d). Hybrid combinations resulted in different signal profiles (column c and e). Note that the images had the same window level.

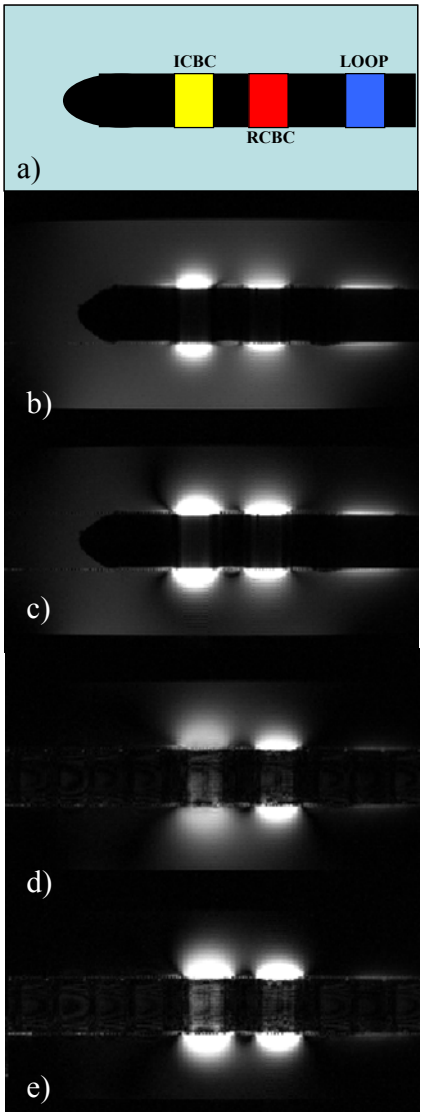

Figure 2: Coronal images of different modes of ICBC, RCBC, and loop coils by using varied transmission and reception combinations.
a) Placement of coils.
b) Forward transmit, forward receive
c) Forward transmit, reverse receive.
d) Reverse transmit, forward receive.
d) Reverse transmit, reverse receive.

CONCLUSION

A new birdcage design as internal coil is proposed. Effectiveness of the new design was shown by phantom images comparing with an active loop coil. Using transmit array system enabled forward and reverse transmissions.

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