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Whole Brain Imaging Using Top-Hat Dipole RF Coil for Better Performance of RF Transmission and Reception at 7 Tesla MRI

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Contents

Introduction

- **Background –** Ultrahigh-field-magnetic resonance imaging (UHF-MRI ≥ 7T) have several advantages such as higher resolution in both anatomical and functional imaging, higher signal-to-noise (SNR) ratio, higher T1, T2, and T2* (susceptibility) tissue contrasts.
- **FOV Limitation** – The commercially head RF coil at 7T MRI is primarily focused on the upper region (e.g., cerebrum, corpus collosum, and cerebellum) of the head and provides less field-of-view (FOV) coverage at the cervical spinal cord (C-spine).
- **Objective** – The main objective of this work is to present the whole brain imaging using limited number of receiver (RX) channels at 7T MR Head Imaging.

Methods

Electromagnetic (EM) Simulations

- EM simulations were performed using Sim4Life [2] to analyze the effect of the proposed RF coil on the B_1^+ field as well as the specific absorption rate (SAR) distribution of transmit RF coil and their respective B_1^- field.
- Figure 1 shows the schematics and configuration of the RF coil with the Duke model.

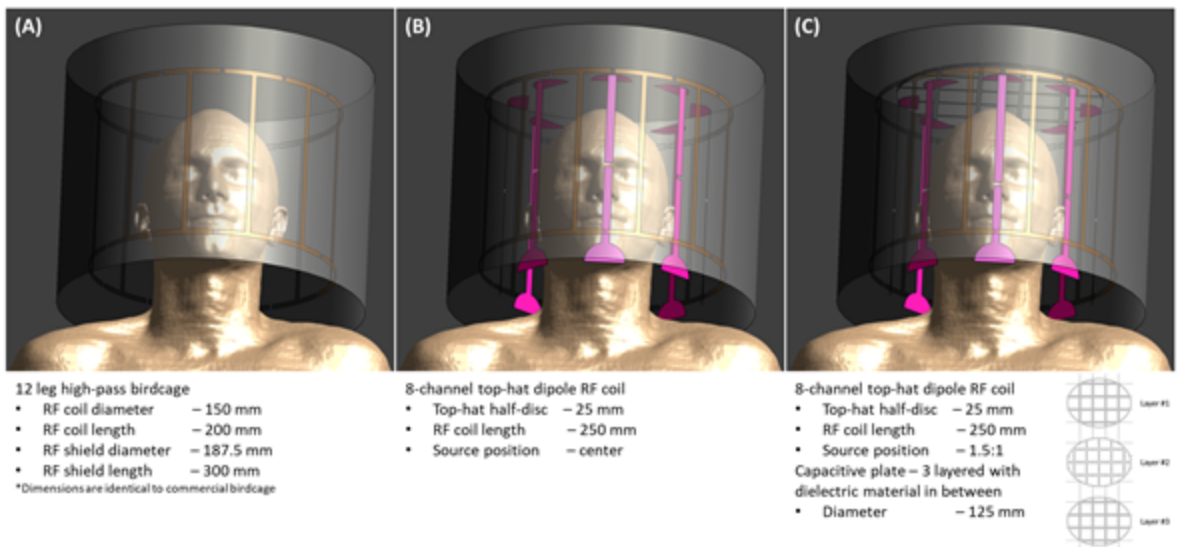

Figure 1. (A) Transmit highpass birdcage RF coil, Configuration of Top-hat dipole receive RF coils (B) without capacitive plate, and (C) with capacitive plate.

Methods

RF Coil Design

- The RF coils were constructed and benchmark tests were performed using the vector network analyzer (VNA).
- The eight-channel top-hat dipole RF coil is constructed by using T-network tuning circuit corresponding to each channel followed by balun and detuning pin-diode (Fig. 2).

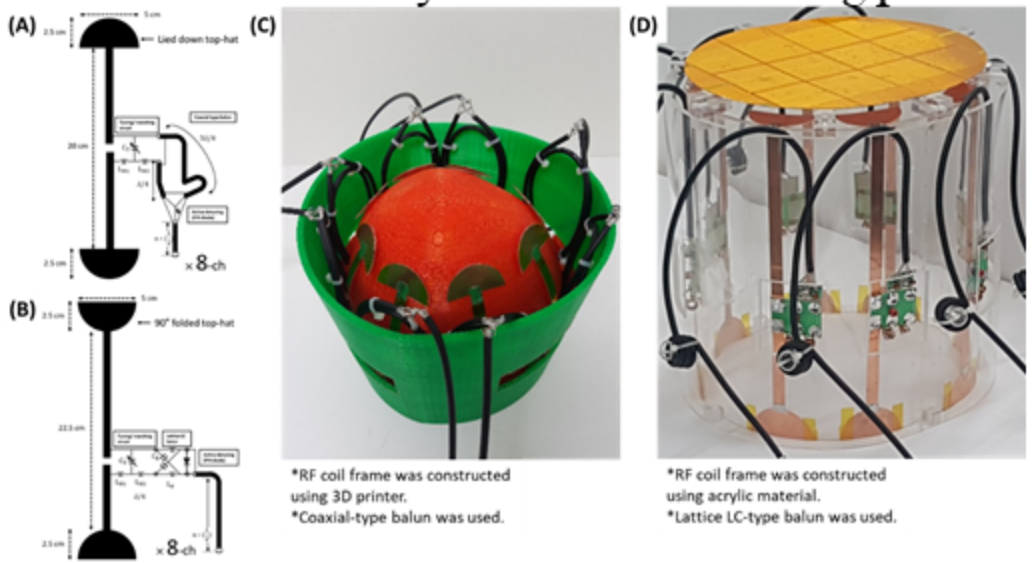

Figure 2. Schematic of the one-channel top-hat dipole antenna comprising a tuning/matching circuit, balun, and active detuning pin diode, using (A) coaxial-type balun, (B) lattice LC-type balun, and constructed eight-channel top-hat dipole antenna (C) without and (D) with capacitive plate, respectively.

Methods

MRI Experiments

- The experiments were performed on 7T MRI (Achieva, Philips Healthcare) available at Korea Basic Science Institute (KBSI), Ochang, South Korea.
- A commercial head birdcage TX RF coil and proposed eight-channel top-hat dipoles RX RF coil with/without capacitive plate were used.
- Following *in vivo* brain MRI experiments were performed:

(i) Flip angle (FA or B_1^+) mapping using dual TR gradient echo (GE) sequence [3],

(ii) High resolution MR images of brain using 3D T1-weighted magnetization-prepared rapid gradient-echo (3D T1w-MPRAGE) sequence, and

(iii) $T2^*$-weighted multiple fast field echo ($T2^*$w-mFFE) sequence.

Methods

Table 1. *In vivo* MRI experiment sequence parameters.

Sequence	Dual TR FA mapping	T1w-MPRAGE	T2*w-mFFE
Nominal FA (°)	60°	7°	17°
TE / TR (ms)	2 / 20,120	2.6 / 5.5 prepulse – invert (1300 ms)	3.6, 9.6, 15.6, 21.6/ 65
FOV (mm^3) **RL x AP x FH**	250 x 260 x 370	250 x 260 x 370	250 x 260 x 370
Acquisition matrix	320 x 320	528 x 528	768 x 768
Voxel size (mm^3)	2.5 x 2.5 x 2.5	0.7 x 0.7 x 0.7	1 x 1 x 2
SENSE factor	2 x 2	2 x 2	2 x 2
Scan time (min)	9 min 13 s	7 min 41 s	4 min 51 s

Results

- The simulated B_1^+ field from the birdcage (TX) only, birdcage (TX)/top-hat dipole (RX) without capacitive plate, and birdcage (TX)/top-hat dipole (RX) with capacitive plate are shown in Fig. 3.
- The magnitude of B_1^+ field was increased by 5.5 % at the center and average 20.5 % at the upper part of the head when the capacitive plate was used.
- The measured reflection coefficient (S_{11}) and the decoupling coefficient (S_{21}) were under −30 dB and −15 dB, respectively.
- The ratio of unloaded to loaded Q (QU/QL) for the top-hat dipole without/with capacitive plate were approximately 4.6 and 4.9, respectively.
- Figures 4 shows the FA maps at the sagittal plane using the top-hat dipole RF coil without/with capacitive plate, which clearly shows the B_1^+ field enhancement and improved coverage using the capacitive plate.
- The T1w-MPRAGE and T2*w-mFFE images at the sagittal plane using the top-hat dipole RF coil without/with capacitive plate showing the anatomical contrast are shown in Fig. 4.

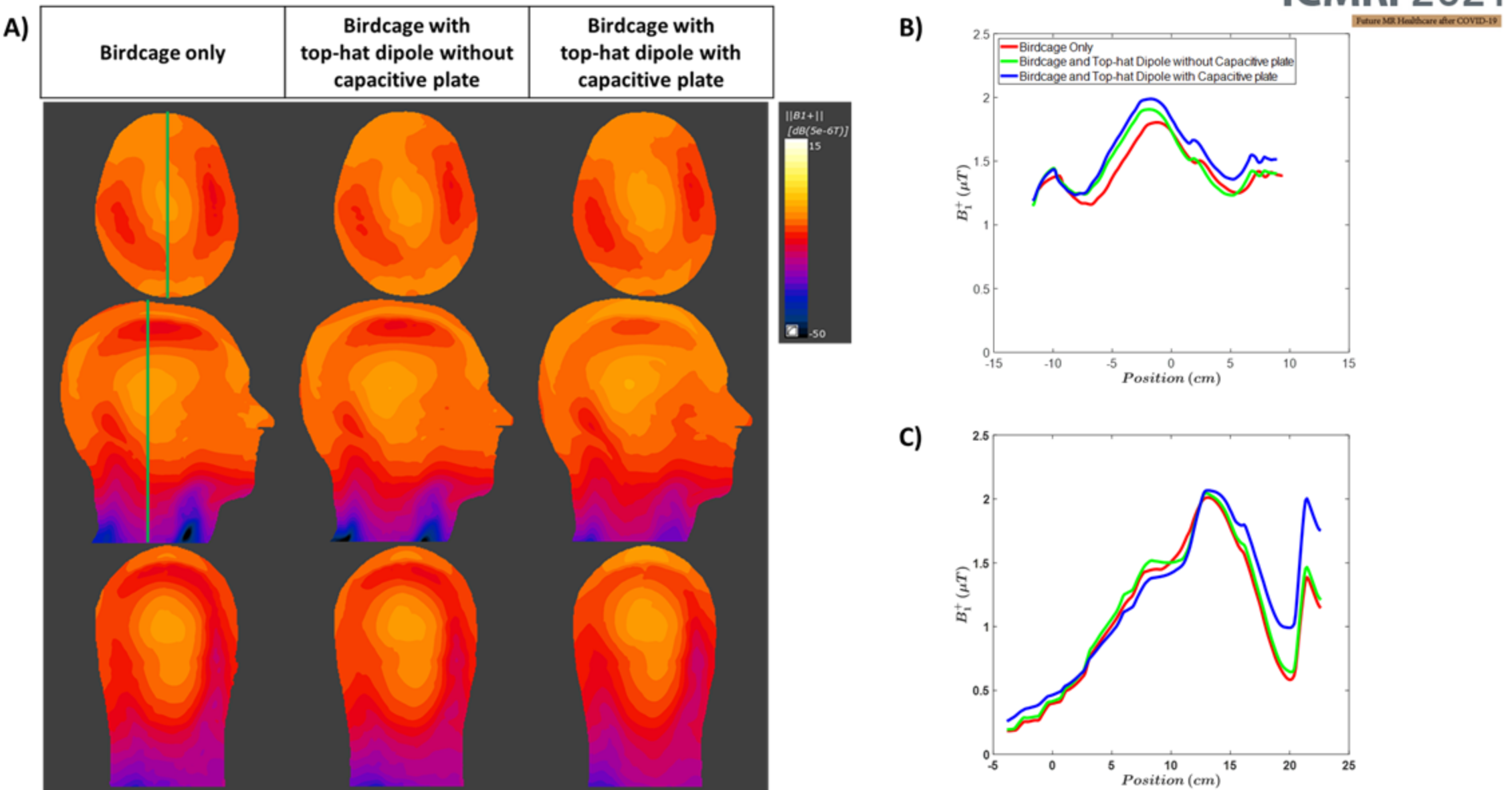

Figure 3. (A) Simulated B_1^+ field, and their respective (B) axial and (C) coronal slice profile.

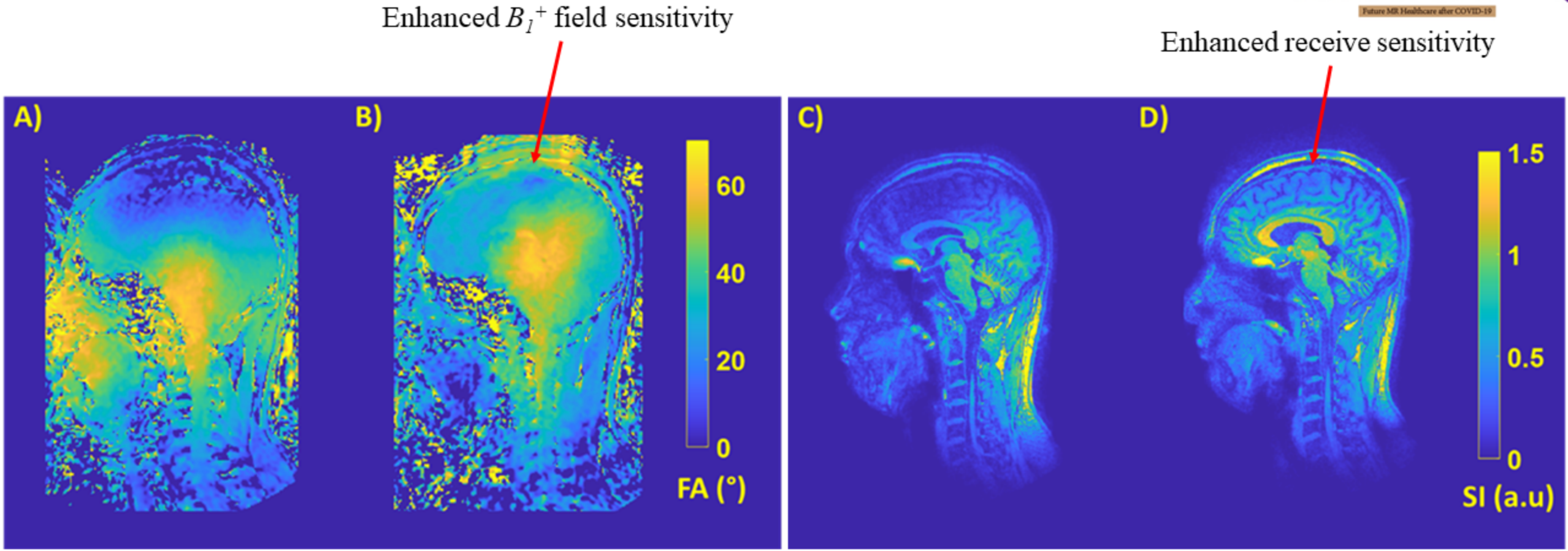

Figure 4. (A, B) FA maps, (C, D) High resolution T1w-MPRAGE images of the brain using the eight-channel top-hat dipole RF coil without and with capacitive plate, respectively. Note: commercial head birdcage coil is used for the transmission.

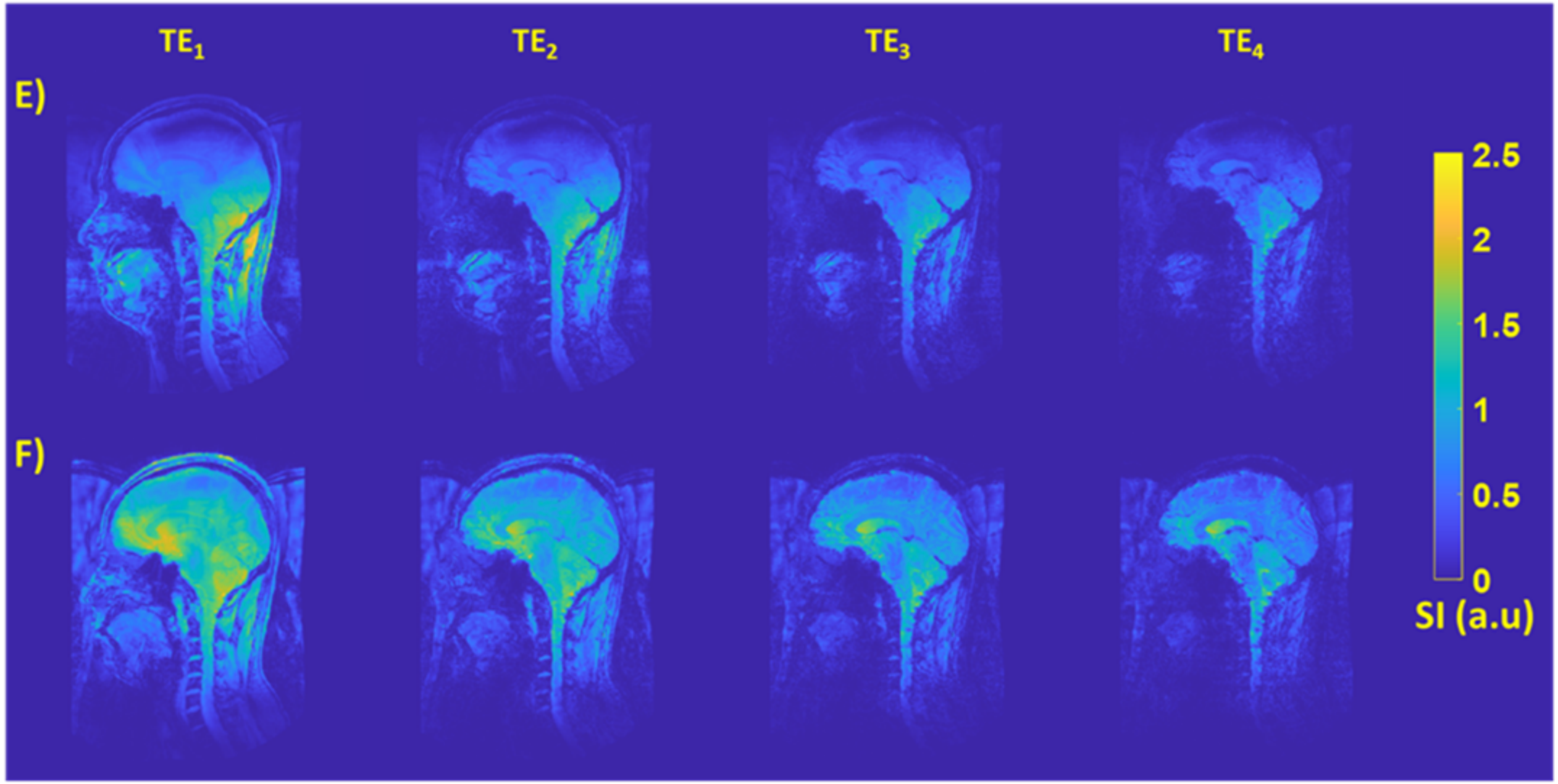

Figure 4. (E, F) T2*w-mFFE images of the brain using the eight-channel top-hat dipole RF coil without and with capacitive plate, respectively. Note: commercial head birdcage coil is used for the transmission.

Discussions and Conclusions

- In this work evaluated the receiver performance of the eight-channel top-hat dipole RF coil with a capacitive plate.
- The proposed receiver RF coil exhibits lower coupling with the transmit RF coil and does not deteriorate the B_1^+ field.
- In addition, the RF coil with a capacitive plate also improves both B_1^+ field distribution as well as receiver sensitivity in the brain and was able to cover the entire portion of the head including the cervical vertebrae at 7T MRI.

Acknowledgement

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Thank You!!!

❖ For any question, see us at Poster Q&A Session: November 5 (Fri), 16:10-17:30. The poster code is P-MR-20.