B1 field optimization for microstrip transmission line volume coil at high field

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Introduction:

The advantage of high field MRI is high SNR which can increase image resolution or decrease acquisition time. However, the 'dielectric resonance' effect (or wavelength behavior) at high field can cause B_1 field inhomogeneity in the human head by using traditional volume coils, such as birdcage. Because changing thickness of the substrate of microstrip transmission line (MTL) coil can change the B_1 field pattern [1], a relatively homogeneous B1 field pattern in human head are expected by selecting the appropriate thickness of the substrate of MTL coil. In practice, it would be costly and time-consuming to build a large number of volume coils with different substrate thickness. In this work, B_1 field distributions within MTL head coils with different substrate thickness were investigated by finite difference time domain (FDTD) method.

Methods:

The FDTD method[2] was used to calculate B_1 field within MTL coils through time-dependent Maxwell's equations at resonance frequency of 170MHz (4T) by the aid of commercially available software XFDTD (Remcom, Inc., State College, PA). A region of interest (ROI), 36X36X41 cm^3 was divided into mesh of 4,644,808 Yee cells where the basic elements of 3D meshes in FDTD method are 1.5mm/cell in X and Y direction, 5mm/cell in Z direction. A 16-element MTL volume coil with 25.4-cm i.d. and 21cm length was modeled in the ROI. The widths of the strip conductors of the MTL resonant elements were 2.54cm. Thickness of substrate of the MTL coil changes from 3mm to 21mm. Copper was modeled as a conductor with conductivity of $5.95x10^7$ S/m. The phantom used in this work is a 15-cm diameter sphere (relative permittivity is 58.255, conductivity is 0.4915 S/m) which can be used to represents average brain tissue at 170MHz (4T). All MTL coils with different thickness of substrate were tuned to 170MHz by changing the relative permittivity of dielectric materials and driven linearly.

Results and Discussion:

The 1D profiles of B_1 field distribution on the central axial plane of unloaded MTL coils with different substrate thickness were shown in Fig. 1. For comparison, the maximum B1 field magnitude was normalized to 1. According to Fig.1, the B1 field homogeneity gradually increases with the substrate thickness increasing. For example, within the central axial plane, the B1 field magnitude variation over distance of 15 cm are 20.3% for MTL coil with 3mm substrate thickness, and14.7% for MTL coil with 21mm substrate thickness.

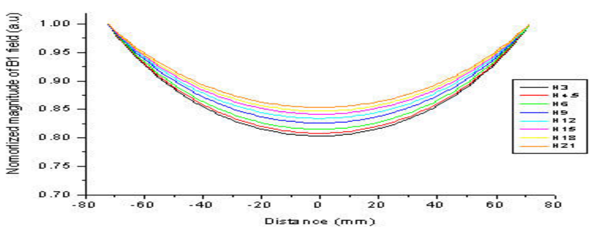

Fig.1 Simulated *B*1 field distributions in the transverse direction for unloaded MTL coils with different substrate thickness. The maximum *B*1 field magnitudes of all coils are normalized to 1.

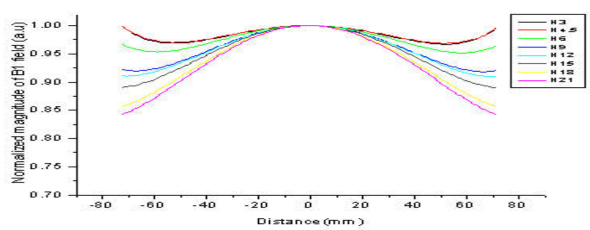

Fig.2 Simulated *B*1 field distributions in the transverse direction for loaded MTL coils with different substrate thickness. The maximum *B*1 field magnitudes of all coils are normalized to 1.

The 1D profiles of B1 filed distribution on the central axial plane of loaded MTL coils with different substrate thickness were shown in Fig.2. The maximum B1 field within each spherical phantom was also normalized to 1. Compared with unloaded case in Fig.1, the 'dielectric resonance' effect is obvious and it can compensate the intrinsic B1 field inhomogeneity of unload MTL coils. According to Fig.2, the homogeneity of B_1 field can be improved by decreasing the substrate thickness of MTL coils from 21mm to 4.5mm. But the homogeneity of B1 field doesn't increase when the substrate thickness of MTL coils decrease from 4.5mm to 3mm, on the contrary, the B1 field homogeneity of MTL coil with 3mm substrate thickness is slightly worse than that of MTL coil with 4.5mm substrate thickness. So, a relatively uniform B_1 distribution within the spherical phantom can be achieve by selecting appropriate thickness of the substrate (4.5mm for this case), and it is also possible to achieving a relatively uniform B_1 field within a human head at high field by changing substrate thickness of the MTL coil elements.

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References:

[1] Zhang X, et al, J Magn Reson (2003) 161:242-251

[2] Yee KS, IEEE Trans. on Ant. And Propag, 1966, 14:302-307