A Dual-Tune Sodium/Proton Tx/Rx 14-channel Sodium and 2-channel Proton Array Breast Coil at 7T

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Introduction: Breast cancer is one of the leading cancers for women. Proton MRI has been frequently used as a diagnostic tool to detect breast cancer. It has good sensitivity but limited specificity [1] which requires additional biopsy procedure for positive diagnosis. It was reported that sodium concentration has significant increase in malignant breast tumor issue and sodium imaging were tried at 3T [2] [3]. Recent development on 7T technology brought more imaging interest to sodium imaging due to higher SNR. Sodium imaging normally requires proton imaging for anatomical reference. Common dual tune coil uses either lossy RF traps or PIN diodes which cause additional SNR loss. Nested approach for dual tune coil doesn't require to use traps or PIN diodes for coil decoupling [4]. This technique was also demonstrated on sodium knee imaging at 7T recently [5]. Here, we have constructed and tested a transmit/receive dual tune sodium/proton array breast coil at 7T using the nested approach.

Materials and Methods: The breast coil was designed for Siemens 7T MAGNETOM MRI System. The mechanical former was built by Stratasys Fortus 3D Production Systems. The former has two dome holes to accommodate both breasts. The dome holes diameter is about 14 cm at opening and about 12 cm in depth (Fig. 1). The coil elements have a three-layer structure. The inner lay is the proton layer. It consists of two loops for each breast. Two loops are combined as a two-turn solenoid for both transmit and receive modes (Fig. 2). The proton coils are tuned at 297.2 MHz. The middle layer is the receiver elements of sodium coil. It consists of 4 loops and 2 saddles for each breast (Fig.3). Each element has decoupling circuit to decouple the coil from sodium transmit B_1 field only. The isolation of sodium receiver elements is achieved by traditional overlap and low impedance preamplifier [6]. The outer layer is the two sodium saddle coils used as both transmit and receive coil (Fig. 2). The two saddles are isolated from each other through overlap and both have good isolations with middle layer elements without overlap. All the sodium coils are tuned and matched at 78.6MHz. The distance between adjacent layers ranges from 5mm to 1cm.

Fig. 1 External view of the breast coil

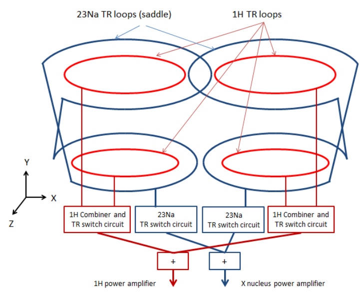

Fig. 2 Inner and outer layer of coil elements

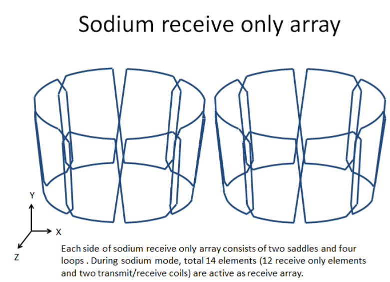

Fig. 3 Middle layer of coil elements

Results and Discussion: The sodium/proton dual tune breast coil was tested on a Siemens 7T system at Medical University Vienna. Routine phantom imaging and safety simulation/test were performed before clinical study. Preliminary clinical test was performed on a healthy volunteer. The images were shown in Fig. 4. Reference proton images were acquired with DIXON sequence (Fig. 4 (a) and (b)). Sodium imaging was measured with UTE sequence (Fig. 4 (c)). The sequence parameters are TR/TE:100/0.07 ms, isotropic resolution 3.13 mm, bandwidth 200 Hz/pixel, 3000 projections, 1 average, and measurement time 5:00 min. The overlay of color-coded sodium image over water Dixon image is show in Fig. 4 (d). The result is promising and further clinical study is required for a solid conclusion.

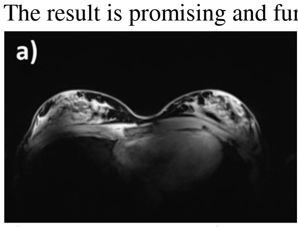

Fig. 4 (a) water DIXON image

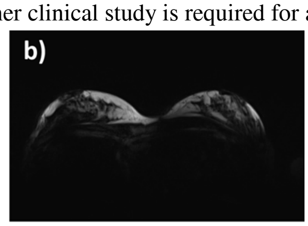

Fig. 4 (b) fat DIXON image

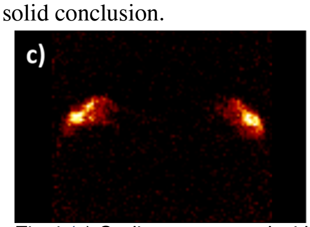

Fig 4 (c) Sodium measured with UTE sequence

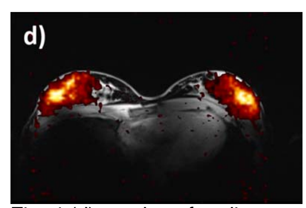

Fig. 4 (d) overlay of sodium over water image

Conclusion : We demonstrate preliminary clinical sodium/proton imaging using a nested Tx/Rx dual tune sodium/proton array coil at 7T. Although further clinical evaluations are needed for a more concrete conclusion, the result shows promising direction.

References

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