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(G) Sodium (23Na) magnetic resonance imaging (MRI) of prostate cancer using an external coil

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Background
Sodium (23Na) magnetic resonance imaging (MRI) can detect the increased tissue sodium concentration (TSC) exhibited in several tumour types. For prostate cancer imaging, 23Na MRI is conventionally performed using an endorectal coil which is associated with a nonuniform sensitivity profile and limited field of view, constraining its clinical utility. To address these challenges, we have developed a completely external, non-invasive 23Na MRI coil to measure TSC differences between prostate cancer and normal tissue.

Methods
MR imaging was performed at 3 Tesla in six healthy volunteers and ten patients with biopsy-proven prostate cancer. The radiofrequency system included an external flexible transmit/receive butterfly coil consisting of two loops (diameters=18cm, tuning=32.6 MHz) built in-house for 23Na MRI. 23Na MRI was acquired using a 3D density-adapted radial projection sequence and a nominal isotropic resolution of 5×5×5 mm3. The normal peripheral zone (PZ), normal transition zone (TZ), and prostate cancer lesions in the PZ and TZ were delineated by a radiologist using only proton MRI datasets. The percent difference in TSC (ΔTSC) between each lesion and surrounding normal PZ and TZ was evaluated using a one-sample t-test. Total TSC was also compared between the patients and volunteers using a one-way analysis of variance and Tukey test for multiple comparisons.

Results
Across ten patients, a total of 13 lesions were detected (8 PZ, 5 TZ). Comparing PZ and TZ lesions to normal PZ and TZ, respectively, the mean ΔTSC (-20.7%) was significantly lower than 0%. There were no significant differences in the TSC of normal tissue between patients (PZ: 74.9 ± 14.4 mM, TZ: 78.9 ± 20.1 mM) and volunteers (PZ: 66.5 ± 12.0 mM, TZ: 63.6 ± 14.4 mM).

Discussion
For the first time, an external 23Na MRI coil was used to quantify TSC in human prostate cancer and normal prostate tissue. In contrast to previous studies employing 23Na MRI endorectal coils, lesions presented with lower TSC compared to surrounding normal tissue. This finding suggests that TSC is influenced in part by differences in cell density. Specifically, many tumour types including prostate cancer are characterized by a denser cellular environment compared to normal tissue, which would decrease total TSC. Future work will focus on establishing the sensitivity of this coil in characterizing tumour aggressiveness using Gleason grade defined by whole-mount histopathology as the ground truth.

Keyword-1

23Na MRI

Keyword-2

human prostate cancer

Keyword-3

tissue sodium concentration

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