Sodium-23 MRI in Prostate Cancer Diagnosis

Prostate cancer (PCa) remains a significant health concern, and the accurate diagnosis and characterisation of its severity are crucial for effective treatment. Currently, biopsy and multiparametric MRI (mpMRI) are standard diagnostic tools, though they are limited in sensitivity and specificity. A novel approach using Sodium-23 (23Na) MRI has been explored to improve the non-invasive assessment of prostate cancer. This imaging technique leverages the altered tissue sodium concentration (TSC) observed in PCa tissues. However, the conventional use of an endorectal coil for 23Na MRI poses challenges, such as non-uniform sensitivity and patient discomfort. A recent review in Radiology Advances examines the feasibility and effectiveness of using an external 'butterfly' coil for Sodium-23 MRI in distinguishing cancerous from noncancerous prostate tissues.

Importance of Sodium-23 MRI in Prostate Cancer

Traditional diagnostic methods like biopsy and mpMRI are standard in prostate cancer evaluation but come with limitations. Biopsies sample only a small fraction of the prostate, risking missed diagnoses or underestimation of tumour grade. Although mpMRI has improved lesion detection and characterisation, it often struggles to differentiate between cancerous and benign tissues. Sodium-23 MRI offers a potential solution by detecting variations in TSC, which are known to occur in cancerous tissue. Because TSC in prostate cancer cells tends to differ from that in normal cells, Sodium-23 MRI could provide complementary information to traditional imaging, thereby enhancing diagnostic accuracy.

The challenge, however, lies in the low signal-to-noise ratio (SNR) of Sodium-23 MRI due to the lower biological abundance of sodium compared to hydrogen (proton-based MRI), as well as technical difficulties with endorectal coils, such as limited field of view and patient discomfort. To address these issues, an external Sodium-23 coil was developed to achieve a better balance between patient comfort, SNR, and image quality. This study aimed to explore the feasibility of using this external coil for whole-gland TSC comparison in PCa and noncancerous prostate tissues.

Study Design and Imaging Methodology

A prospective study was conducted to quantify TSC differences in the prostate using an external Sodium-23 MRI coil. Six healthy male volunteers and 20 participants with biopsy-proven PCa underwent imaging sessions between January 2022 and June 2024. The Sodium-23 MRI was performed using a custom-built two-loop "butterfly" coil, while mpMRI was utilised as a clinical reference. By comparing the TSC in cancerous lesions and surrounding noncancerous tissues, researchers sought to identify any significant variations in TSC that could indicate the presence of cancer.

The study involved acquiring images in both the peripheral zone (PZ) and transition zone (TZ) of the prostate. The results showed that cancerous prostate lesions presented significantly lower TSC compared to noncancerous tissues, particularly in the TZ. The difference in TSC between cancerous and noncancerous tissue was around -14.1%, which was statistically significant. Additionally, as expected, the apparent diffusion coefficient (ADC), a parameter measured in mpMRI that reflects tissue cellularity and structure, was lower in cancerous lesions. This combined approach of TSC and ADC analysis could potentially improve PCa characterisation and grade assessment.

Advantages and Challenges of Using an External Sodium-23 Coil

The external Sodium-23 MRI coil offers several advantages over conventional endorectal coils. It provides whole-gland coverage, higher patient comfort, and uniform sensitivity profiles. Unlike endorectal coils, which suffer from signal drop-off away from the coil centre, the external coil design ensures more consistent imaging across the prostate. This is particularly beneficial for detecting lesions in different zones of the prostate, such as the TZ, where mpMRI faces challenges in differentiating between cancerous and noncancerous tissue.

However, some limitations remain. While the external coil showed promise in detecting sodium signals throughout the prostate, there was no significant difference in TSC in the PZ between cancerous and noncancerous tissues. This finding may be due to the looser stromal structure and larger extracellular space in the PZ, leading to inherently higher TSC and potentially obscuring differences between healthy and cancerous tissue. Additionally, the study had a relatively small sample size, and most of the PCa cases were of intermediate risk, potentially limiting the generalisability of results to low- and high-risk cases. Future studies should explore the coil's performance across a broader spectrum of PCa grades.

The use of an external Sodium-23 MRI coil for assessing tissue sodium concentration in the prostate has appeared to be feasible. The findings suggest that PCa lesions have a significantly lower TSC than noncancerous tissues, especially in the TZ, making this technique a promising non-invasive approach for PCa diagnosis. Combining TSC data with mpMRI-derived ADC values enhances the potential for more accurate PCa detection and characterisation. While the results are promising, further research with larger, more diverse cohorts is needed to validate these findings and explore the external coil's utility in differentiating between low- and high-risk PCa.

The development of external coil technology represents a significant step forward in the non-invasive imaging of prostate cancer. This technology could supplement existing diagnostic tools and improve the precision of PCa diagnosis and management, offering patients a less invasive and potentially more reliable assessment method. Future advancements in Sodium-23 MRI and external coil design could pave the way for widespread clinical adoption, providing a powerful tool in the fight against prostate cancer.

Source: Radiology Advances
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