BAINES IMAGING

When Seeing Is Not Believing: Eye-Tracking Evidence of Missed Prostate Cancer on mpMRI

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INTRODUCTION

- The Prostate Imaging – Reporting and Data System[1] (PI-RADS) guidelines provide standardized procedures for prostate cancer (PCa) identification on multiparametric magnetic resonance imaging (mpMRI).
- PI-RADS recommends the use of T2-weighted (T2w), apparent diffusion coefficient (ADC) map derived from diffusion-weighted imaging (DWI), and T1-weighted dynamic contrast-enhanced (DCE).[1]
- Despite PI-RADS providing a standardized framework, studies found sensitivities ranging between 65–97%,[2] suggesting some PCa is still missed on mpMRI.
- Tumours often missed were 2–3 times smaller than identified tumours and contained lower Gleason grades.[3-5]

It is unknown whether radiologists miss these tumours due to classification errors (i.e. eye gaze fixates on tumours sufficiently, but misclassifies), or search errors (i.e. eye gaze fixates on tumours insufficiently, causing missed tumours).

- One way to accurately assess radiologist detection performance is through co-registered whole-mount histopathology ground truth labels.
- To our knowledge, there have been no studies that investigate the use of eye tracking technology to study radiologist fixation times for co-registered histologically defined PCa detection on mpMRI.

OBJECTIVE

Primary objective: to characterize the relationship between detection of histologically defined PCa and radiologist fixation times on mpMRI.

- Secondary objective: to examine PI-RADS score distributions as a measure of post-hoc, per-lesion classification confidence among radiologists of varying levels of experience.

METHODS

- A cohort of 40 patients with biopsy-proven PCa who elected to undergo radical prostatectomy was used for this research.
- Patients had pre-surgical mpMRI and post-prostatectomy whole mount histopathology registered using a fiducial-based registration algorithm.[6]
- Four board-certified radiologists with varying levels of experience were tasked to search for PCa according to PI-RADS, during which eye tracking data were collected, followed by contouring each tumour identified during their search.
- During contouring, radiologists assigned a PI-RADS 3–5 score on T2w, ADC, and DWI, and a binary enhancement score (zero or one) on DCE.
- The total time on the tumour was calculated by summing all fixation durations ≥200ms during which the parafovea overlapped with the tumour for each mpMR image.
- Sensitivity and positive predictive value (PPV) were calculated to evaluate detection performance.

RESULTS

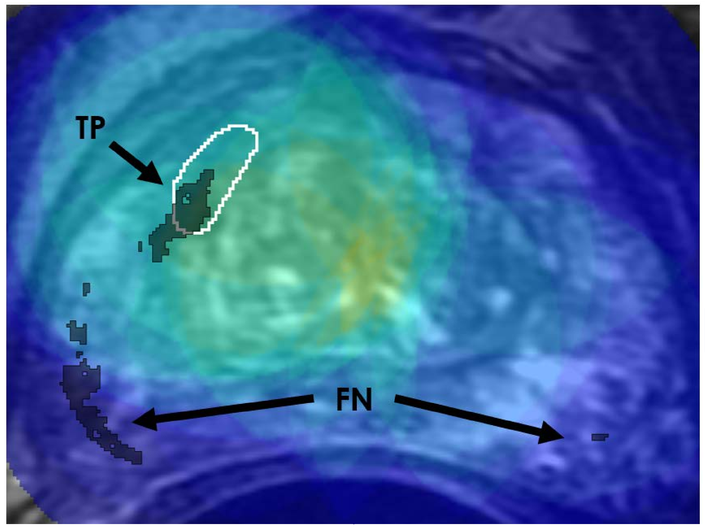

Figure 1: The time spent fixating on different regions of the T2w MRI using parafoveal vision with histologically-defined PCa defined by the black contours and Rad. 1 contour of suspected regions of PCa defined by the white contours. TP = true positive, FN = false negative.

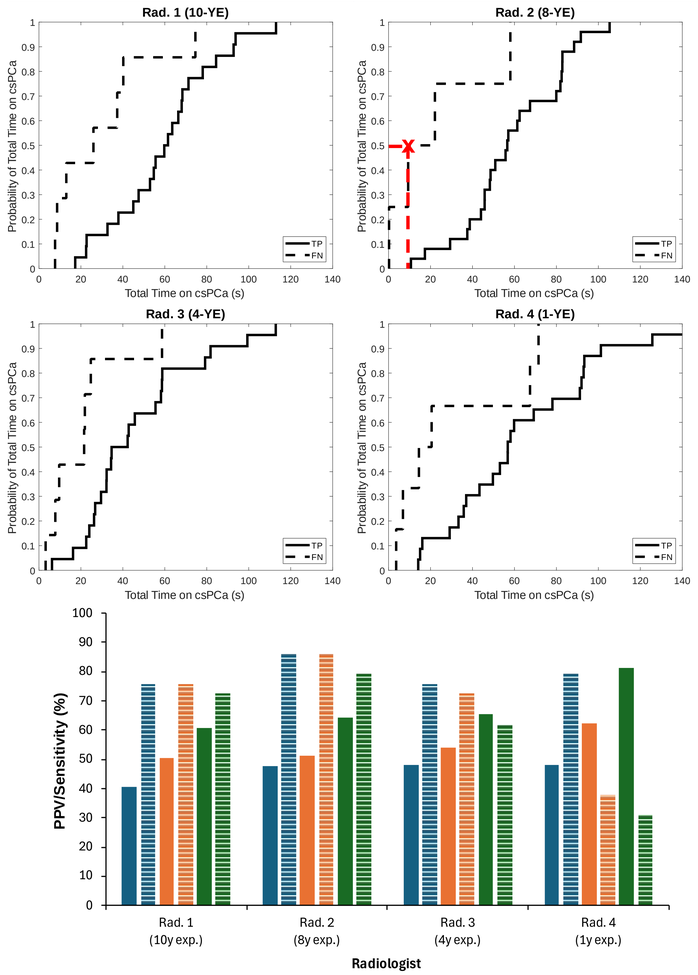

Figure 2: The cumulative distribution function for the total time foveating on PCa on all mpMRI sequences for **a)** Rad. 1, **b)** Rad. 2, **c)** Rad. 3, and **d)** Rad. 4. The red X and dashed line in b) provide an example for how to interpret these distributions; 50% of the time spent fixating on FN tumors for Rad. 2 were below 9.35 seconds. Rad. = Radiologist, TP = true positive, FN = false negative, YE = years of experience.

Figure 3: Radiologists' overall sensitivity and positive predictive value (PPV) at different PI-RADS score thresholds.

DISCUSSION & CONCLUSION

- False negative mpMRI calls on clinically significant, histologically confirmed tumors were not due to radiologists missing them during search.
- Radiologists spent more time foveating on true positive tumors, compared to false negative tumors, suggesting that they incorrectly ruled out cancerous tumors more quickly than they ruled them in.

First study to evaluate the relationship between eye tracking metrics and PCa detection on mpMRI.

- Equivocal (PI-RADS 3) scores were assigned most often by the least experienced radiologist, suggesting reduced classification confidence, impacting detection of PCa.
- A potential limitation may be the uncertainty of the eye tracker, which was reported as ±1° equating to 15 mm in MRI space; some fixations may have been incorrectly classified as falling within or outside true positive and false negative tumor regions, particularly for fixations near tumor boundaries.

FUTURE WORK

- Have residents complete the study to determine whether sufficient search and detection proficiency can be reached after receiving radiologist and histology contour feedback.
- Develop a training tool that exposes residents to optimal search patterns to develop proficiency.
- Train artificial intelligence to accurately identify prostate cancer using eye tracking data and voice command to enable physician-AI feedback loop.

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