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Comparison of Endorectal coil and Non-endorectal coil T2W and DW MRI at 3T for Localizing Prostate Cancer: Correlation with Whole-mount Histopathology

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Abstract

Purpose—To compare utility of T2W and DW MRI obtained with and without an endorectal coil at 3T for localizing prostate cancer.

Materials and Methods—This IRB approved study included twenty patients (median PSA 8.4ng/mL). Patients underwent consecutive prostate MRIs at 3T, first with a surface coil alone, then with combination of surface, endorectal coils (dual coil) followed by robotic assisted radical prostatectomy. Lesions were mapped at time of acquisition on dual-coil T2W, DWI-MRI. To avoid bias, six months later non-endorectal coil T2W, DWI-MRI were mapped. Both MRI evaluations were performed by two readers blinded to pathology with differences resolved by consensus. A lesion-based correlation with whole mount histopathology was performed.

Results—At histopathology 51 cancer foci were present ranging in size from 2 to 60mm. The sensitivity of the endorectal dual-coil, non-endorectal coil MRIs were 0.76, 0.45, respectively. PPVs for endorectal dual-coil, non-endorectal coil MRI were 0.80, 0.64, respectively. Mean size of detected lesions with non-endorectal coil MRI were larger than those detected by dual-coil MRI (22mm vs. 17.4mm).

Conclusion—Dual-coil prostate MRI detected more cancer foci than non-endorectal coil MRI. While non-endorectal coil MRI is an attractive alternative, physicians performing prostate MRI should be aware of its limitations.

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Keywords

prostate cancer; surface coil; endorectal coil; MRI; 3 Tesla

INTRODUCTION

MRI is emerging as an important tool for localizing prostate cancer (1–13). This success is based on several factors: improved signal-to-noise ratios derived from the use of combined endorectal and surface coil arrays, higher field strength magnets, and the expanded use of multiparametric magnetic resonance imaging (MRI) (T2 weighted [T2W] MRI, diffusion weighted [DWI] MRI, MR spectroscopy and Dynamic Contrast Enhanced [DCE] MRI). Despite an extensive supportive literature on prostate MRI, endorectal coil MRI is still not commonly used; contributing factors include anticipated discomfort associated with the endorectal coil, costs related to reimbursement of the coil and lack of expertise. Avoiding the need of an endorectal coil could improve the palatability of prostate MRI from the physicians', payors' and patients' perspective. Recently, several groups have reported comparable performance between non-endorectal coil MRI of the prostate at 3T and endorectal dual coil MRI at 1.5T (2, 7, 14–17). However, the number of studies in which direct comparisons of endorectal dual coil and non-endorectal coil MRI done at 3T is still limited (7). Herein, we compared the utility of non-endorectal coil and dual coil (surface and endorectal coils) T2W and DWI MRI of the prostate at 3T for localizing prostate cancer by using whole mount histopathology as a reference.

MATERIALS AND METHODS

Study design and population

This prospective, single institution study was approved by the local institutional review board and was compliant with HIPAA; informed consent was obtained for all patients. Eighty-four consecutive patients with a mean age of 60.6 years (median 59.7, range 33.6–85 years) and a median serum PSA of 6.8ng/ml (range 0.71–455ng/ml) were enrolled in the study between March 2010 and September 2010. Final inclusion criteria included having non-endorectal coil (surface coil only) and dual coil (endorectal coil and surface coil) MRI at 3T in the same imaging session followed by a robotic assisted radical prostatectomy.

The final study population consisted of 20 patients with a mean age of 61.3 years (median 60, range 50–74 years) and a median serum PSA of 8.4ng/ml (range 3.18–48.9ng/ml). Clinical staging were T1c in 18 patients, T2a in 1 patient and T2b in 1 patient. Exclusion criteria included not having robotic assisted radical prostatectomy after MRI (n=64).

MR Imaging

All MRI studies were performed on a 3T magnet (*Achieva, Philips Medical Systems, Best, The Netherlands*). Initially, each patient was scanned with only the 6-channel cardiac coil (*SENSE, Philips Medical Systems, Best, The Netherlands*). The MRI protocol included triplanar T2W turbo spin echo (TSE) and DWI MR sequences. DCE MRI could not be obtained due to inclusion in the subsequently acquired dual coil study in the same session.

Specific imaging parameters are summarized in Table 1. Following the non-endorectal coil MRI, a dual coil MRI (surface and endorectal coils) was performed using a combination of an endorectalcoil (*BPX-30, Medrad, Pittsburgh, PA, USA*) tuned to 127.8 MHz and a 16-channel anterior cardiac coil (*SENSE, Philips Medical Systems, Best, The Netherlands*) without prior bowel preparation. The endorectalcoil was inserted using a semi-anesthetic gel (*Lidocaine, AstraZeneca, USA*) while the patient was in the left lateral decubitus position. The balloon surrounding the coil was distended with perfluorocarbon (*3 mol/L-Fluorinert, 3M, St. Paul, MN, USA*) to a volume of approximately 45 mL to reduce susceptibility artifacts induced by air in the coil's balloon. The MR imaging protocol included triplanar T2W TSE, DWI MRI, 3D MR Spectroscopy imaging (MRSI), axial pre-contrast T1W, axial 3D fast filed echo dynamic contrast-enhanced (DCE) MRI sequences. Parameters of dual coil T2W and DW MRI are presented in Table 2.

MRI and Histopathology Analysis

Following robotic radical prostatectomy, the specimen was fixed in formalin for 2–24 hours at room temperature and then was placed in the customized 3D MRI-based mold and sliced in axial 6mm sections (18). Endorectal dual-coil MR images were evaluated and lesions were mapped prospectively in consensus by two experienced radiologists. MR images obtained with the surface coil alone were evaluated by the same two radiologists, blinded to pathology results, 6 months later to extinguish memory of the original interpretation. For both techniques, on T2W MR images and ADC maps of DW MRI, the criterion for a "visible" lesion was having a well-circumscribed, round-ellipsoid low-signal-intensity region within the prostate gland (10). DCE MRI and MR spectroscopy assessments were not performed during the evaluation of endorectal dual-coil T2W MRI and ADC maps.

Whole mount histopathology specimens sectioned in the customized dual coil MRI-based mold were mapped for each individual tumor focus, reporting the dimensions and Gleason scores, independently by an experienced pathologist, who was blinded to the MRI. The results of non-endorectal coil and endorectal dual coil prostate MRI scans were stringently correlated with whole mount histopathology by using a lesion-based analysis. Additionally, for each patient, a dominant or index tumor was identified based on its having the largest dimensions and the highest Gleason score on the entire prostatectomy specimen (19). Sensitivity of endorectal dual coil MRI and non-endorectal coil MRI were assessed in the detection of the dominant tumor.

Statistical Analysis

Sensitivity and positive predictive values (PPV) were estimated based on all lesions. Specificity and negative predictive value determinations were not possible to evaluate since a lesion-based correlation method was applied. The mean detected and missed tumor sizes at both MRI techniques were compared by student t-test and p-values <0.05 were considered to be statistically significant.

RESULTS

Whole mount histopathology analysis revealed 51 tumors (n=13 Gleason 3+3, n=35 Gleason 3+4, n=2 Gleason 4+4, n=1 Gleason 4+5) in 20 patients. 16 tumors were localized in the transition zone, whereas 35 were located within the peripheral zone and the average tumor diameter was 15mm (median 11mm, range 3–60mm). Evaluation of endorectal dual coil MRI scans revealed 49 lesions; the sensitivity and PPV of endorectal dual coil MRI were 0.76 and 0.80, respectively. Mean (median) diameter of detected and missed tumors were 17.4mm (15mm) and 7.2mm (4mm), respectively. Non-endorectal coil MRI evaluation revealed a total of 36 lesions; sensitivity and PPV of non-endorectal coil MRI were 0.45 and 0.64, respectively. Mean (median) diameter of detected and missed tumors were 22mm (24mm) and 9.2mm (10mm), respectively. Although the mean diameter of detected lesions with endorectal dual-coil MRI were smaller than that of non-endorectal coil MRI, the difference was not significant (*p=0.13*) (Figures 1 and 2) (Table 3).

Twenty dominant tumors were identified in 20 patients. Endorectal dual-coil MRI was able to detect 17 of 20 dominant tumors, yielding a sensitivity of 0.85, whereas non-endorectal coil was able to detect 15 of 20, resulting in a sensitivity of 0.75.

As a side result, 5 lesions had extracapsular extension at histopathology and 4 of them were detected with endorectal dual-coil MRI, whereas only 1 was depicted with non-endorectal coil MRI.

DISCUSSION

Our results show that endorectal dual coil MRI is more sensitive in the detection of prostate cancer lesions than non-endorectal coil MRI. Even when considering only the dominant lesions, the non-endorectal coil MRI performed slightly worse than the endorectal dual coil MRI in depicting the tumors. Although the difference was not significant, the tumors detected by non-endorectal coil MRI tended to be larger. A possible explanation for this can be lower in-plane resolution for the non-endorectal coil MRI. Thus, while non-endorectal coil MRI offers a less invasive alternative to endorectal coil MRI, it may not be an equal substitute for endorectal dual coil MRI.

Prior studies evaluating non-endorectal coil MRI of the prostate have mainly focused on the utility of this technique in tumor staging, including extracapsular extension and seminal vesicle invasion detection, and few of them have focused on tumor detection which is becoming an increasingly common indication for prostate MRI (2, 7, 14–17). Heijmink et al. reported a sensitivity, specificity and PPV for non-endorectal coil 3T MRIs as 0.27–0.45, 0.78–0.93, and 0.79–0.83, depending on reader experience (7). In our study, the sensitivity and PPV for non-endorectal coil MRI were 0.45, 0.64, respectively.

It has been established that dual surface and endorectal coils improve the image quality and performance of prostate MRI (10). Thus, the findings in this study are not unexpected; however the magnitude of the difference in sensitivity between those 2 techniques has not been explored. This data suggests that the non-endorectal coil MRI is able to detect large tumors, especially dominant tumors, which are believed to be the driving force of prostate

cancer prognosis (20). However, non-endorectal coil MRI was not always able to detect these tumors missing extracapsular extension in 4 of 5 lesions. A dual coil MRI is not always available; therefore, an understanding of the implications and limitations of a non-endorectal coil examination should be understood.

It could be argued that the endorectal dual coil method simply detects more prostate cancers which could lead to over treatment. However, some of these lesions could be life threatening. Methods are under development to detect “lethal signatures” based on biopsy specimens of prostate cancer and this may influence the conservative management of these small, detected lesions. However, until it is possible to predict which tumors will progress to metastases based on genomic profiling or immunohistochemitry, Gleason scoring and lesion size are the only currently established parameters for estimating tumor aggressiveness. In this regard, non-endorectal coil MRI missed a significant number of lesions.

A limitation of our paper is that we used a 6 channel cardiac coil during non-endorectal coil MRI scans, whereas combinations of 16 channel anterior cardiac coil and endorectal coils were used during dual coil MRI scans. This can potentially create a negative bias against the non-endorectal coil technique and may not reflect a one-to-one comparison of surface and endorectal coil methods, however this experiment was conducted as part of the clinical standard of care and at that time it was not possible to use a 16 or 32 channel coil alone. Another limitation of this study is that we included a comparison of only T2W MRI and DWI MRI, but not dynamic contrast enhanced MRI or MR spectroscopy, since it was not feasible to repeat all dual coil sequences in a single session on the same day. T2W MRI and DWI MRI are considered the most important among those used for multiparametric imaging. DCE MRI and MRSI can be positive when T2W and DWI MRI are negative but this is unusual. However, it remains possible that the results might have improved (for both dual coil and non-endorectal coil) with the addition of DCE MRI or MRSI. Finally, the study population was relatively small, but included a sufficient number of tumors (n=51) to compare those two MRI techniques. Although, we conducted this experiment in 84 consecutive patients, only 20 of them underwent radical prostatectomy and all of their whole mount histopathology specimens were available for using as a gold standard. This 20/84 ratio is also reflecting the real proportion of the patients undergoing surgery who are referred to our clinic for prostate MRI.

In conclusion, T2W and DW MRI of the prostate obtained at 3T with combined endorectal and 16-channel surface coil is more sensitive for detecting intraprostatic lesions and detects more cancers than the MRI obtained without an endorectal coil. Non-endorectal coil MRI tends to identify larger tumors but can miss smaller, significant tumors. It is important for imagers to understand the tradeoffs involved when deciding whether to employ non-endorectal coil or endorectal dual coil prostate MRI.

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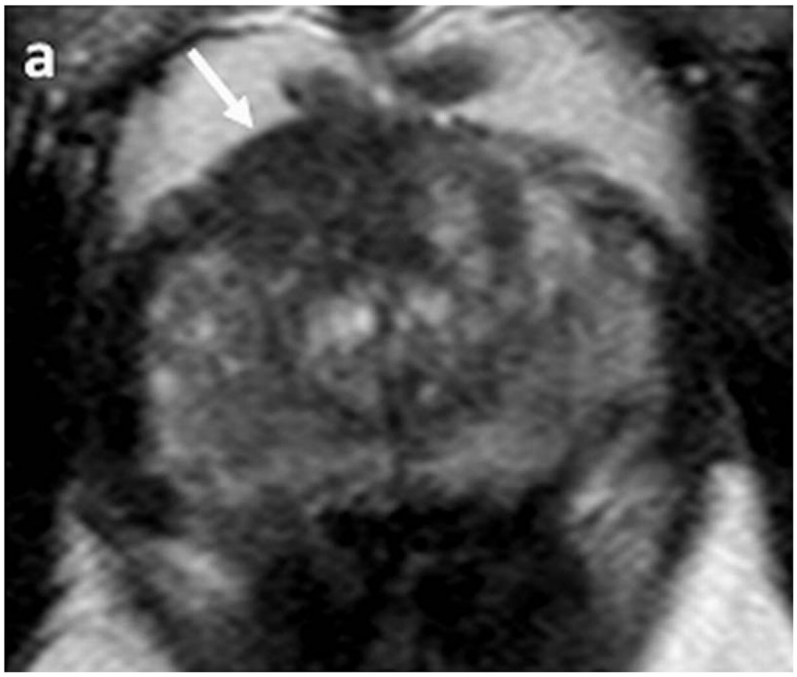
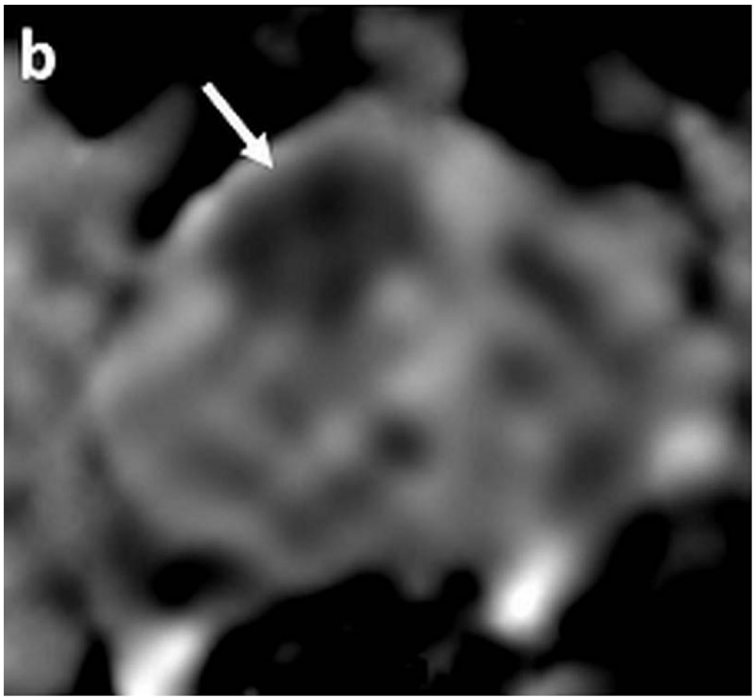
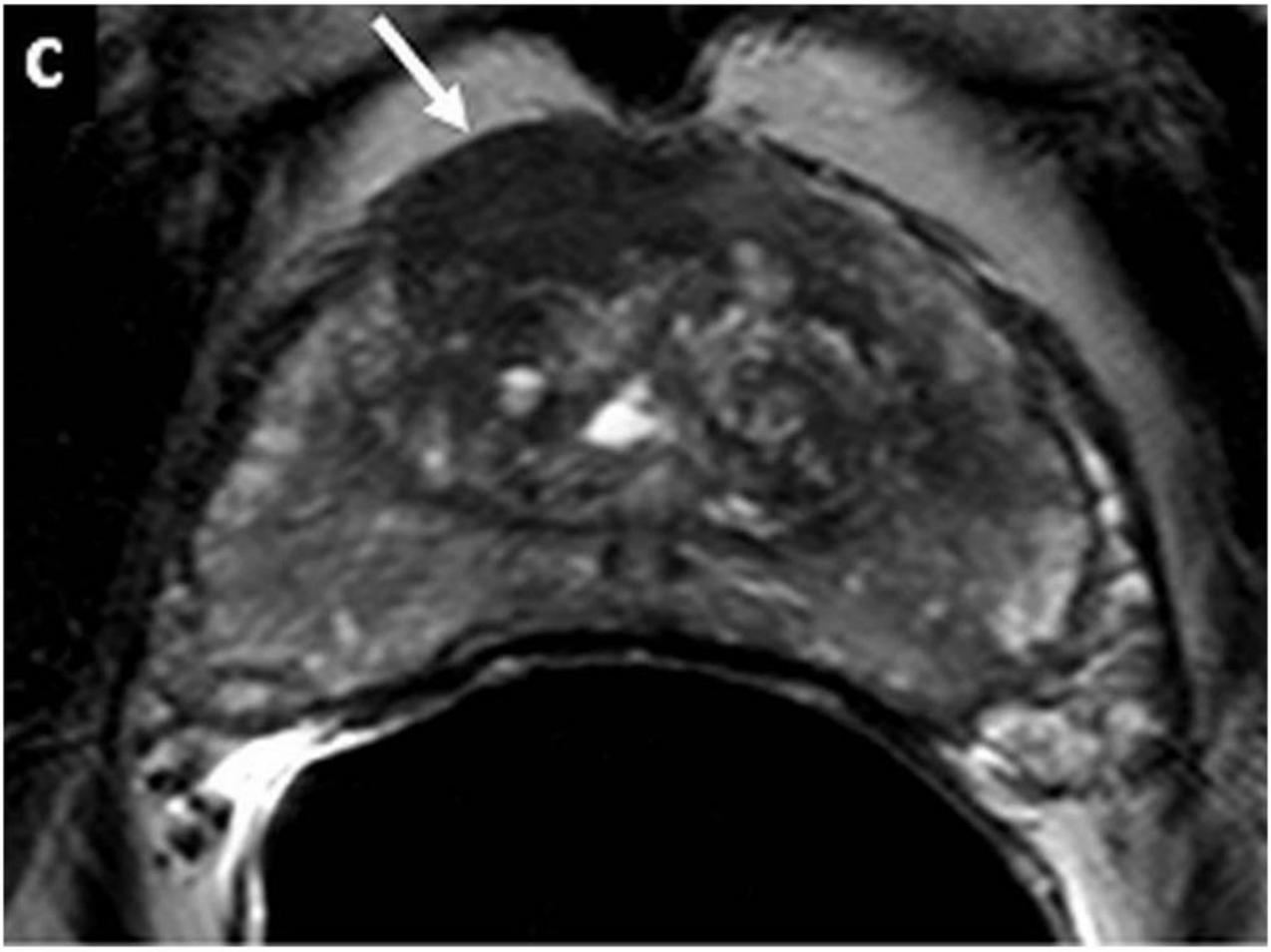
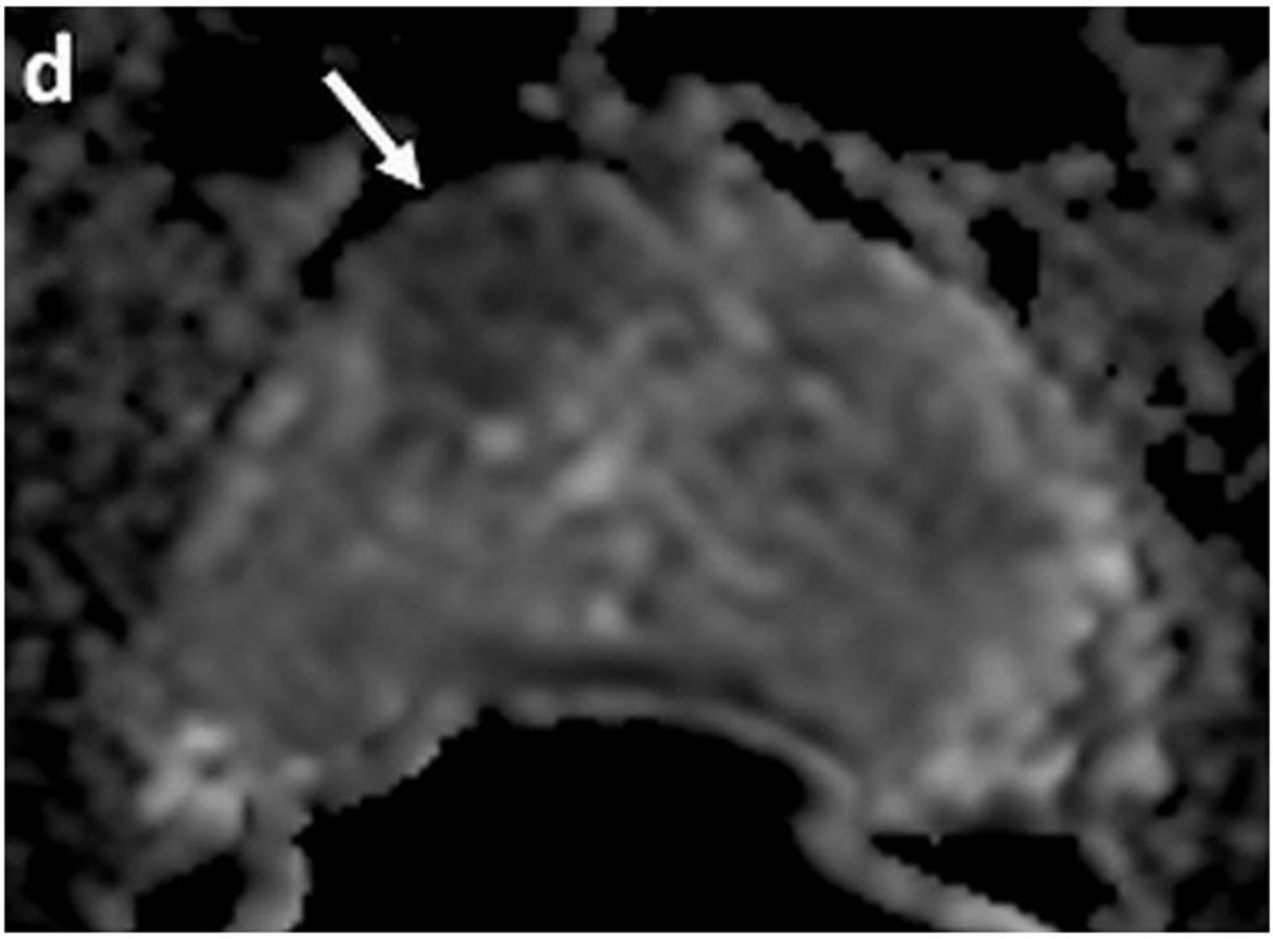








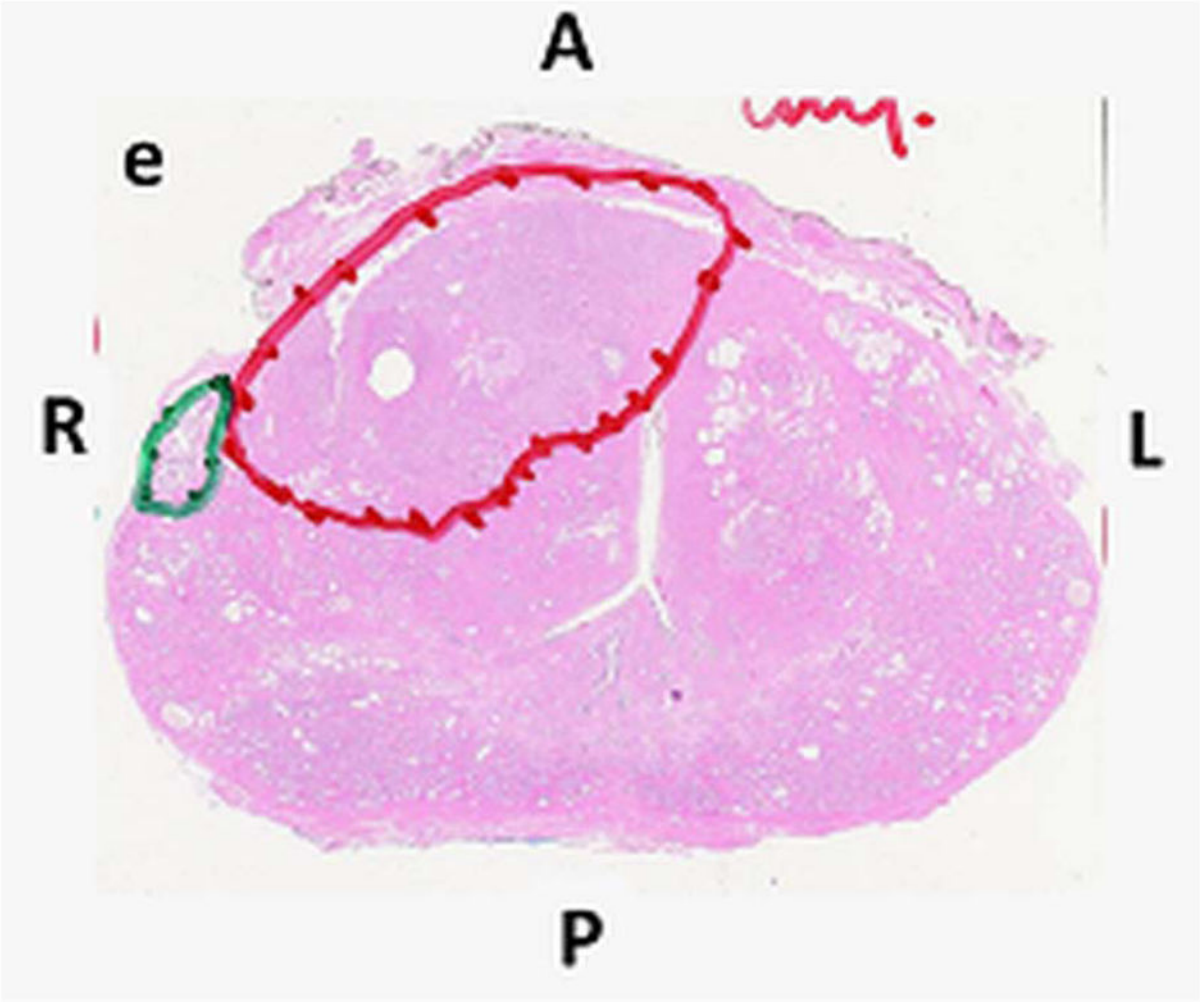
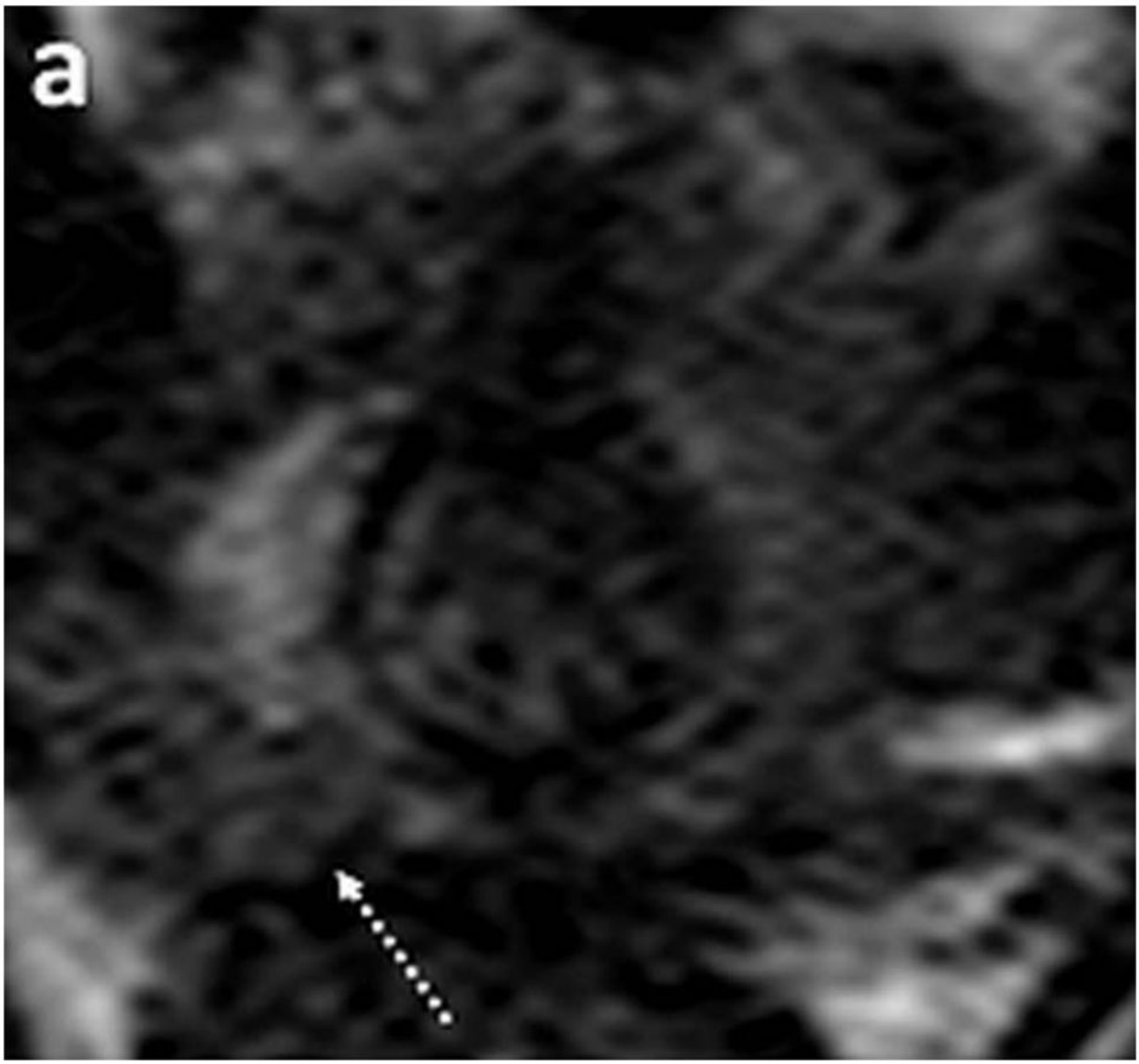
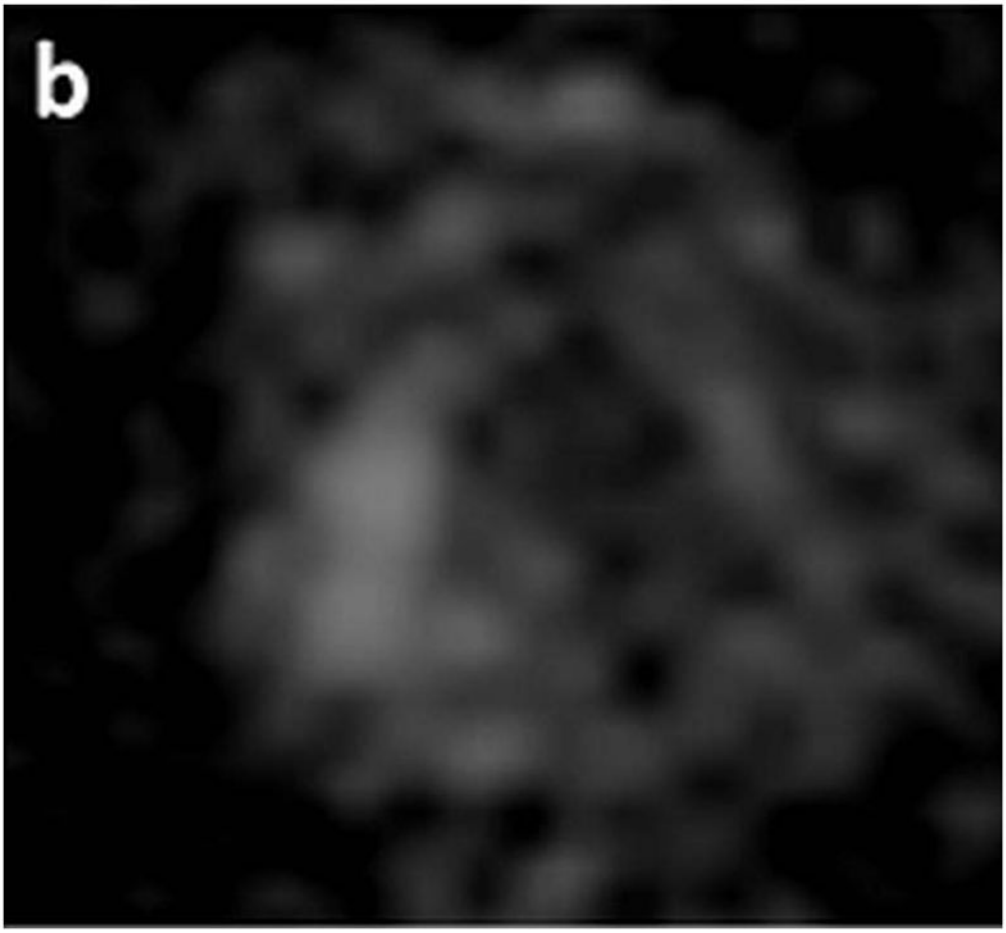
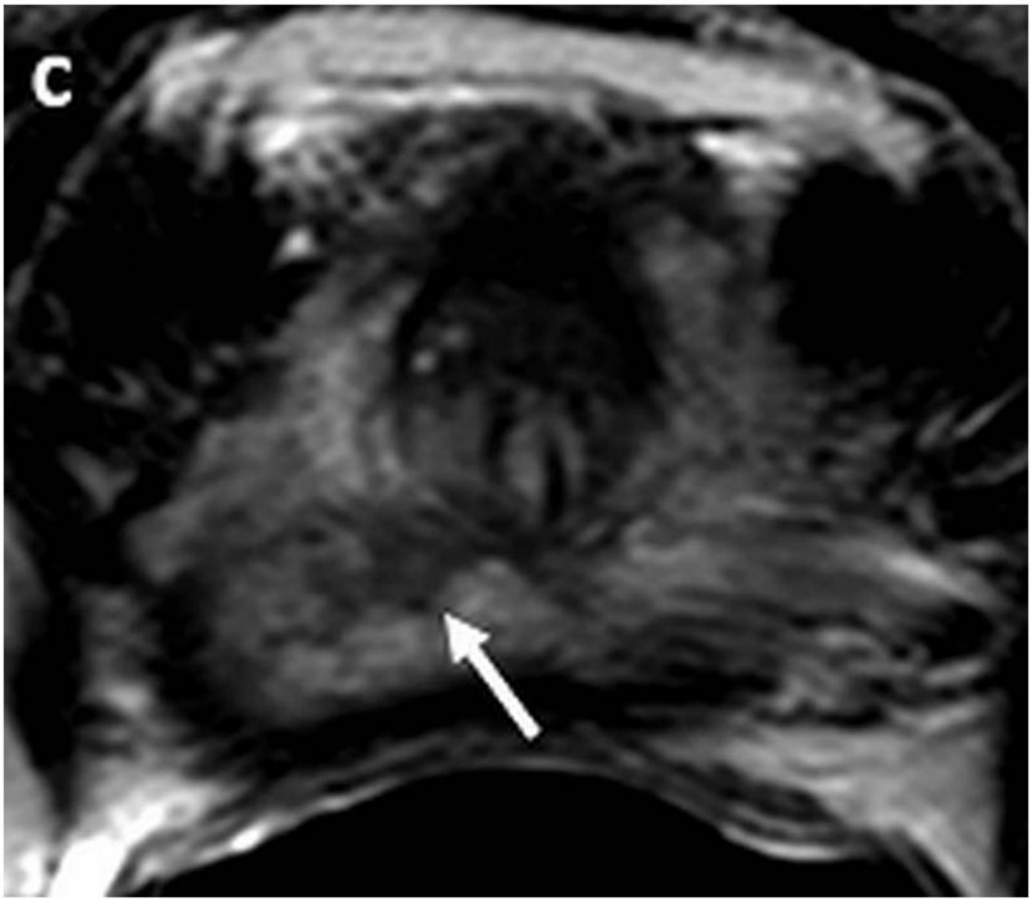


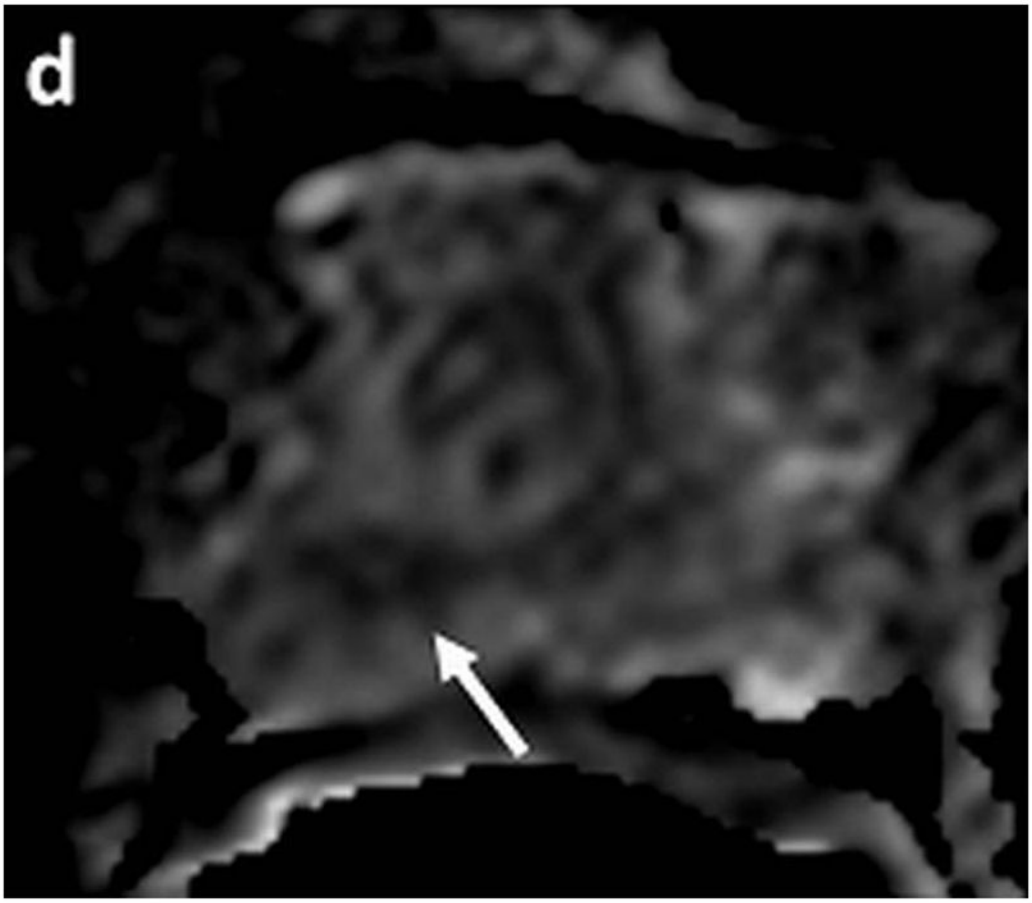
Figure 1.

70-year-old man with a serum PSA of 26.6ng/dl and T1C clinical disease. Axial T2W MRI (a) and ADC map of DWI MRI (b) obtained with non-endorectal coil technique and axial T2W MRI (c) and ADC map of DWI MRI (d) obtained with endorectal dual coil technique demonstrate a right mid anterior transition zone lesion (arrows in a–d). Corresponding histopathology map shows a Gleason 3+4 tumor (inked in red), which was the dominant lesion in this patient and a focus of prostatic intraepithelial neoplasia (inked in green) (e) (R: right, L: left, A: anterior, P: posterior).









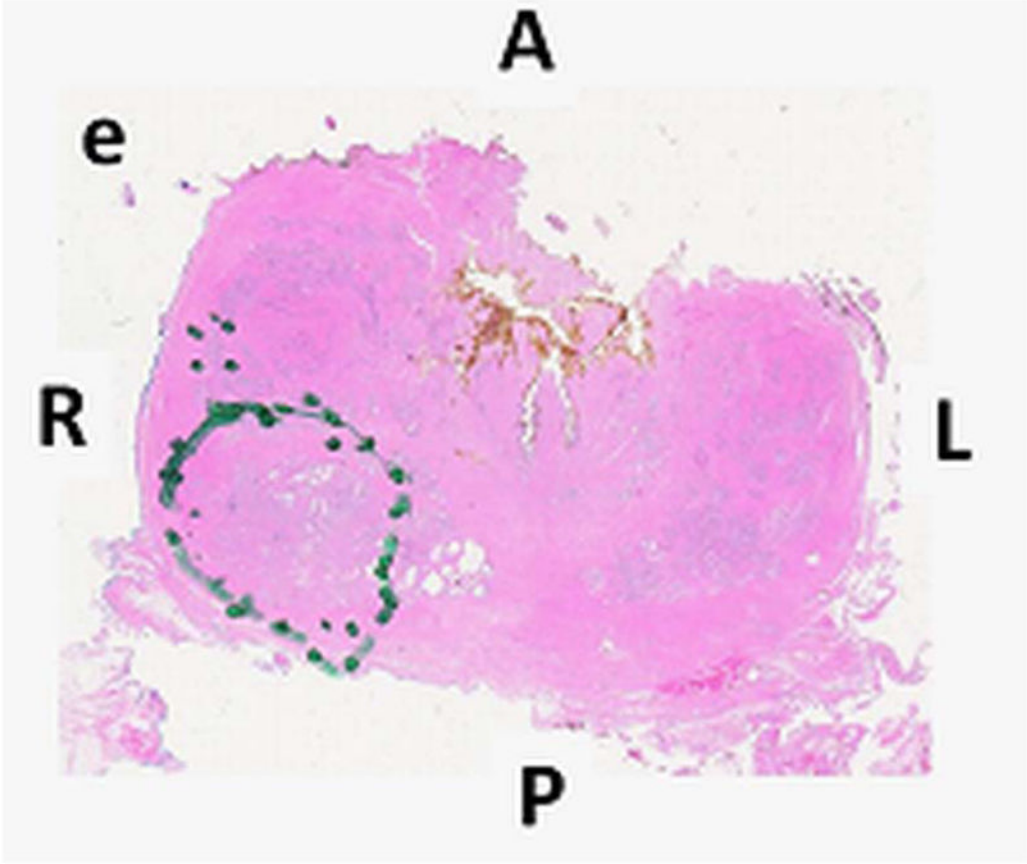


Figure 2.

65-year-old man with a serum PSA of 17.1ng/dl and T1C clinical disease. Axial T2W MRI obtained with non-endorectal coil technique (a) shows a barely visible lesion in the right low apical peripheral zone (dashed arrow), which was prospectively missed by the readers of the study; whereas ADC map of DWI MRI (b) obtained with the same technique shows no evidence of lesion; however axial T2W MRI (c) and ADC map of DWI MRI (d) obtained with endorectal dual coil method demonstrate a right low apical peripheral zone (arrows in c and d). Corresponding histopathology map (e) shows a 0.8cm Gleason 3+4 tumor focus (inked in green), which was not the dominant tumor lesion in this patient.

Table 1

Parameters used in a surface coil alone 3T prostate MRI;

Surface Coil Alone MRI Parameters						
MRI Sequence	**TR/TE (msec)**	**FOV (mm)**	**Matrix**	**Flip angle (degree)**	**Slice thickness (mm)**	**Scan time (minutes)**
Sagittal T2W TSE	3000/120	180	180×169	90	3	2.66
Axial T2W TSE	5324/120	180	320×216	90	3	4
Coronal T2W TSE	3620/120	180	320×216	90	3	3
[+]*Axial DWI MRI*	5850/76	180	128×127	90	3	4

[+](2 b values [0 and 600] were used) (number of signal averages used for T2W TSE scans was 3).

Table 2

Parameters used in dual coil 3T prostate MRI;

Dual Coil MRI Parameters						
MRI Sequence	**TR/TE (msec)**	**FOV (mm)**	**Matrix**	**Flip angle (degree)**	**Slice thickness (mm)**	**Scan time (minutes)**
Sagittal T2W TSE	2340/120	140	304×234	90	3	1.66
Axial T2W TSE	8852/120	140	304×242	90	3	5.66
Coronal T2W TSE	2340/120	140	304×242	90	3	2.5
[+]*Axial DWI MRI*	4140/57	160	112×108	90	3	5

[+](5 evenly spaced b values between 0 and 750 were used) (number of signal averages used for T2W TSE scans was 2).

Table 3

Sensitivity and positive predictive value of endorectal dual coil and non-endorectal MRIs with respect to whole mount histopathology. The mean diameters of missed and detected lesions with both techniques are also presented (numbers in parentheses represent the median value). There was no significant difference between diameters of missed and detected lesions.

Results for Non-endorectal and Endorectal Dual Coil MRI				
	Sensitivity	**Positive predictive value**	**Mean diameter of detected lesions (mm)**	**Mean (median) diameter of missed lesions**
Endorectal dual-coil MRI	0.76	0.80	17.4 (15)	7.2(4)
Non-endorectal coil MRI	0.45	0.64	22(24)	9.2 (10)