Radiological-Pathological Correlation of Prostate Carcinoma: Our Initial Experience with 3T MRI (T2 and DWI) in a General Radiology Department

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Purpose

To evaluate the sensitivity for detecting prostate carcinoma and extracapsular extension with 3T MRI in a general regional radiology department, and to identify any specific limitations.

Prostate cancer is the most common noncutaneous malignancy in the western world, with 1 in 6 men diagnosed during their lifetime [1,2]. The current diagnostic workup involves a combination of digital rectal examination (DRE), serum prostate specific antigen (PSA) testing and trans-rectal ultrasound guided biopsy (TRUS).

In the current management paradigm, prostate MRI has two main indications [2,3]. Firstly, it is used for detection of clinically significant tumour in patients with low risk or negative biopsy results and high PSA. A reassuring MRI in this setting confirms that active surveillance is the correct course of management, while a concerning MRI helps direct where to target on repeat biopsies. Secondly, it is used to locally stage intermediate and high risk patients to determine the presence of extracapsular extension (stage 3 disease) - given that if present, the risks of surgery outweigh the benefits [4].

This study was undertaken after upgrading the department's MRI from 1.5 to 3T. Both urology and radiology departments were keen to determine how well prostate cancer could be assessed with the new equipment - with a view to learning and improving the local management of what is a common condition that causes extensive morbidity throughout the community.
Methods and Materials

20 patients with biopsy proven prostate carcinoma were examined with 3T MRI prior to radical prostatectomy. T1, DWI, ADC and multiplanar T2 sequences were performed. Assessment of the presence and location of both intra-prostatic tumour and extracapsular extension was performed radiologically and pathologically and the results were compared.

Dynamic contrast enhancement was also undertaken, however it did not add extra value to the T2 and DWI sequences, as well as being cumbersome to perform (due to PACS and workstation issues). Endorectal coils were not used as the literature is mixed [2,5-8], the extra costs are significant and patient discomfort may have been a disincentive for participation.

Each study was double read by any 2 of a group of 4 general radiologists - determining the presence and location of tumour, and whether or not extracapsular extension was present radiologically. The post-surgical specimens were also assessed for the same features by a single uropathologist and the results were compared.

The findings were further discussed at a multidisciplinary meeting with the radiologists, surgeons and pathologist. Where there was a discrepancy between the radiology report and the pathology, the cases were reviewed to determine whether this was due to an error in interpretation, image quality or a limitation of MRI.
Results

Excluding those cases with significant artifact, the sensitivity for tumour detection was 71% (specificity 71%), and 75% for macroscopic ECE (specificity 100%).

Of the 20 studies performed, 3 were significantly degraded - 2 by a large amount of gas in the rectum (e.g. Fig. 1 on page 7) and 1 by metallic hip prosthesis (Fig. 2 on page 7).

The entire tumour was accurately demonstrated in only 1 of the remaining 17 patients (Fig. 3 on page 8). Tumour was partially detected on MRI in 11 and not seen in 5. Of the 5 cases in which tumour was not seen, 3 were of minimal tumour volume (<0.4ml) and 1 was anterior. There was only a single peripheral zone tumour in which there was reasonable tumour volume (0.7ml) and satisfactory image quality where the cancer was not able to be detected. However, this was of low Gleason grade (3+4). Tumour was overcalled in 5 - all 5 showed T2 hypointensity, however only one of these cases demonstrated restricted diffusion.

Extracapsular extension was present histologically in 6 patients, however only 4 of these had macroscopic extension. MRI correctly detected 3 out of 4 of these macroscopic cases. A large amount of gas artefact was thought to account for the extracapular extension not being detectable in the 4th case. The two cases of microscopic ECE were not detectable on MRI.

Discussion

The findings supported much of what is in the literature about the limitations of prostate MRI - which helped both Radiology and Urology departments have a first hand understanding about the performance of 3T MRI in our department.

The lessons summarised from this and the associated review of the literature were several fold:

• Minimise artefact:

Artifact from gas in the rectum completely obscured the prostate on DWI sequences (Fig. 1 on page 7). We now encourage patients to empty this completely prior to the
examination. The single case with metallic hip prosthesis was completely unusable on DWI (Fig. 2 on page 7).

- **Sensitivity for detecting intra-prostatic tumour is dependent on multiple factors:**

  **Tumour volume:**

  Our findings were supportive of those of Roethke et al, who concluded that MRI could not exclude tumour with a volume under 0.4ml [9]. In our study, excluding those with significant artifact, 0/3 were seen below 0.4ml and the smallest tumour volume detected was 0.45ml.

  Sensitivity for detection of tumours over 0.4ml was 86%, compared to 71% overall (Fig. 4 on page 9).

  **Tumour location:**

  Sensitivity was reduced for anterior tumours, with 0/4 seen radiologically (2 were of volume <0.1ml). Central tumours are also notoriously difficult to detect, though the single central zone tumour in our series was demonstrated (Fig. 5 on page 10).

  Radiological difficulty with anterior and central/transitional zone tumours are well documented [2, 10-12]. This is unfortunate, given they are blindspots on DRE as well. Studies have indicated sensitivity in these areas can be improved with multiparametric MRI (increases accuracy from 64-79%), and that ADC and DCE are the most sensitive techniques in the central and anterior gland [13,14].

  **Tumour grade:**

  Tumour grade affected sensitivity significantly, for both T2 and DWI. Excluding those with artifact, the figures for these are listed in Table 1 on page 11.

  The single tumour that was easiest to detect had the highest grade in the series, Gleason 5+4 (Fig. 3 on page 8).

  Similar patterns of increased detection with increased tumour grade have been demonstrated in multiple previous studies [15,16]. This is particularly the case with ADC - where darker signal correlates with higher grade, and spectroscopy - where (Choline + Creatine)/Citrate ratio in a lesion correlates to Gleason grade [17-22].
MRI's weakness in not being able to detect low grade or low volume tumours may be a blessing as there is some evidence that these patients may do better without undergoing operative treatment. The PIVOT study showed that prostatectomies only reduced mortality in patients with PSAs greater than 10 ng/ml and in patients with intermediate to high risk tumours [23]. In the future, MRI may be able to be used as a triage tool for patients whose initial biopsy shows low grade tumour. An MRI scan in these cases could be performed to look for evidence of high grade disease; if none is found the patient could be observed. If there is evidence of higher grade disease, then a more targeted biopsy of this area could be performed. However more research is required to determine if this hypothesis is valid.

- **Prostate MRI is more specific than sensitive for detecting ECE:**

Overall, sensitivity and specificity for ECE detection were 50% and 100% respectively. If focal ECE was disregarded (only visible under high magnification microscopy - see Fig. 6 on page 11), our sensitivity rose to 75%, though the sample size was too small to consider the findings significant (n = 4). Notably, the single missed case of macroscopic extension was affected by moderate artifact from gas in the rectum.

Meta-analysis in 2002 by Engelbrecht et al (146 studies between 1984-2000), established a joint maximum sensitivity and specificity of 71% for staging by MRI [8]. For extracapsular extension specifically, the reported sensitivity (29-80%) and specificity (47-100%) vary widely - though it is generally appreciated that it is more specific than sensitive [3,4,24-28]. Factors that have been implicated in improving staging accuracy include using multiple planes, addition of DCE to T2 sequences and being a more experienced reader [8,29-31].
**Fig. 1:** DWI image degraded by gas in rectum

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**Fig. 2:** DWI image unusable due to artifact from hip prosthesis

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**Fig. 3:** The only case in the series which radiologically demonstrated the entire tumour. It was both the highest grade (Gleason 5+4) and largest volume (24ml), with ECE. T2 (left); ADC map (right).

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Fig. 4: Sensitivity Vs Tumour Volume

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Fig. 5: Central zone tumour (volume 5.5ml). T2 (left); ADC map (right).

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<table>
<thead>
<tr>
<th>Gleason Grade</th>
<th>% T2 +ve</th>
<th>% DWI +ve</th>
</tr>
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<tbody>
<tr>
<td>3+4</td>
<td>38</td>
<td>12.5</td>
</tr>
<tr>
<td>4+3</td>
<td>100</td>
<td>28</td>
</tr>
<tr>
<td>≥ 4+4</td>
<td>100</td>
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</tbody>
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Table 1: T2 and DWI Sensitivities Vs Tumour Grade

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Fig. 6: Axial T2; Focal ECE - Difficult to call radiologically. Suspicion should be raised by length of abutment (12mm) and capsule bulge.

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Conclusion

Using T2 and DWI sequences, detection of both intraprostatic tumour and extracapsular extension was reasonable, with several limitations highlighted. Tumour was not reliably detected if it was of small volume (<0.4ml), low grade (Gleason 3+4) or anteriorly located. Extracapsular extension was only detected if it was macroscopic.

This study was performed to determine the accuracy of 3T MRI for both the detection and local staging of prostate cancer at our institution - a general regional hospital radiology department.

Overall sensitivity for the detection of intraprostatic tumour was 71% (specificity 71%). However, when tumours with a volume less than 0.4ml were excluded, this figure rose to 86% (specificity remained at 71%). Sensitivity was also affected by tumour grade, with 100% of tumours Gleason 4+3 or higher at least partially detected on T2 imaging.

Sensitivity and specificity for determining macroscopic extra capsular extension were 75% and 100% respectively, though the sample size was very small (n=4). There were 2 additional cases of focal microscopic extension that were expectedly not detected.

Several of the major current limitations were emphasized - particularly with respect to small tumour volume, low tumour grade, difficulty identifying anterior tumours and inability to demonstrate microscopic ECE.

Overall, our results were encouraging - though a larger sample size would have improved the power of the conclusions. Despite this, the study was a valuable exercise for both Radiology and Urology departments, as both teams were left with a greater understanding about both the role and limitations that prostate MRI currently has in the management of such a pervasive disease.
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References


