

MRI OF THE PROSTATIC CANCER: *IN VIVO* AND *IN VITRO* MRI RESULTS COMPARED TO PATHOLOGICAL FINDINGS

Kazuo NISHIMURA, Shuichi HIDA, Kenichiro OKADA
and Osamu YOSHIDA

*From the Department of Urology, Faculty of Medicine, Kyoto University
(Director: Prof. O. Yoshida)*

Kazumasa NISHIMURA

*From the Department of Nuclear Medicine, Faculty of Medicine, Kyoto University
(Director: Prof. J. Konishi)*

Magnetic resonance imaging (MRI) of the prostate was accomplished in 23 patients who had prostatic cancer histologically proved by needle biopsy. Five prostates resected out of 23 patients with prostatic cancer were available for *in vitro* MRI. The MRI findings of the normal peripheral zone of the prostate had a high signal intensity on T2 weighted image, and the cancer nests in the peripheral zone had lower signal intensity than the normal peripheral zone. A partial or total destruction of the border line between outer zone and inner zone was observed besides than microscopic invasions. MRI also enabled us to differentiate the cancerous foci from the normal tissue at a different signal intensity of imaging in some selected cases in which the resected specimen was examined by *in vitro* MRI.

MRI thus appears to be of clinical value in local staging of the prostatic cancer.

Key words: MRI, Prostatic cancer, Pathological specimen, *In vitro* MRI, *In vivo* MRI

INTRODUCTION

Many imaging modalities have been applied for staging of prostatic cancer, but they have a limited role. Computed tomography (CT) can sometimes detect extracapsular extension of cancer, lymphadenopathy, and bone metastasis. However, it can detect neither cancer confined within the capsule nor subtle extracapsular invasion^{1,2)}. Ultrasonography, especially transrectal sonography, can often detect intraglandular changes but is nonspecific. It can show neither lymphadenopathy nor bone metastasis³⁾.

The newly developed MRI has been reported to be useful for the evaluation of the prostate. The fact that no respiratory motion influences the pelvic anatomy and its ability to produce images in multiple planes make MRI very suitable for making exact images of the pelvic organs.

We have examined the correlation be-

tween *in vitro* MRI of the resected prostatic cancer, pathological specimen findings of each corresponding slice, including *in vivo* MRI, to determine whether it is possible to distinguish prostatic cancer from the normal prostate on MRI.

PATIENTS AND METHOD

Twenty-three males (age range 62~85) with pathologically proved prostatic cancer were examined by MRI. Six cases of prostatic cancer had radical prostatectomy and 5 out of 6 served for *in vitro* MRI. Gross sections of the resected specimens were made, and H.E. staining was done. They were examined microscopically. The microscopic findings, and T1 and T2 weighted images of *in vitro* MRI were compared with the findings of *in vivo* MRI and ultrasonography. These analyses were done at the most corresponding cut surface in each examination. MRI of the pelvis was performed using a supercon-

Table 1. Results of the comparative study between *in vitro* T2 weighted MRI and the surgical specimen.

case	findings of <i>in vitro</i> T2 weighted MRI	findings of surgical specimen
case 1	outer zone ; 4 low intensity areas inner zone ; 1 suspicious area partial destruction of the border line between the inner and the outer zone	4 cancer foci 1 cancer focus cancer invades into the inner zone
case 2	outer zone ; 3 low intensity areas inner zone ; 1 suspicious area	2 cancer foci 1 cancer focus
case 3	outer zone ; 2 low intensity areas inner zone ; no suspicious area	2 cancer foci 1 cancer focus
case 4	diminishment of the border line between the inner and the outer zone	the entire prostate was replaced by cancer.
case 5	outer zone ; 2 low intensity areas	1 cancer focus

ducting magnet system (Signa ; General Electric Corp. Milwaukee), operating at 1.5T. T1 weighted images were obtained using the spin-echo TE 40, and TR 600, and T2 and proton density weighted images were obtained using a partial saturation method TE 20 and 60, in combination with TR 2000. *In vitro* MRI was performed within 3 hours of removal, being wrapped airtight in a nylon membrane and positioned in 25-cm-circumference head-coil or surface coil MR unit.

RESULTS

There were no nodular images among the T1 weighted image of *in vitro* and *in vivo* MRI except those taken by surface coil images. However, both *in vivo* and *in vitro* T2 weighted images were spotted images with a double structure, and the inner and outer zones were depicted.

Table 1 shows the results of this comparative study between *in vitro* T2 weighted MRI and surgical specimens. Cancer foci in the outer zone, always had a low intensity, whereas the normal outer zone had a high intensity (sensitivity 100%, predictive value 81.8%). When cancer invaded into the inner zone from the outer zone, destruction of the border line between the inner and outer zones was observed (sensitivity 100%). However, it was difficult to detect cancer foci in the inner zone (sensitivity 66.7%).

In vitro MRI of case 1, stage D1 (T4N2MO), was studied by using a surface coil. The T1 weighted image of *in vitro*

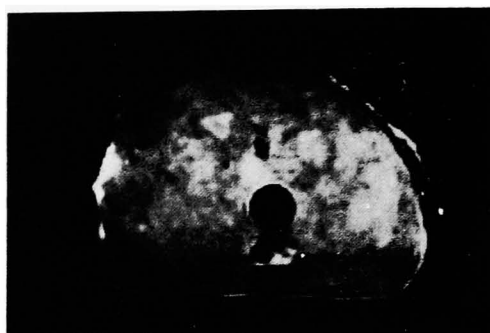


Fig. 1. T1 weighted image of case 1, *in vitro* MRI. On the T1 weighted image, the inner and outer zones cannot be distinguished, and cancer foci cannot be identified.

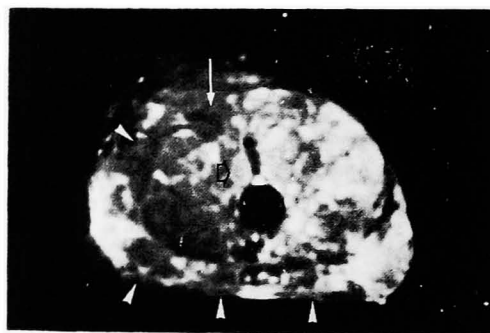


Fig. 2. T2 weighted image of case 1, *in vitro* MRI. Part of the demarcation between the internal and outer zones is obliterated (arrow), and a low intensity area is noted in part of the outer zone (arrowhead). The large arrowhead indicates a BPH nodule.

MRI showed a nodular appearance in almost all parts (Fig. 1). The T2 weighted image of *in vitro* MRI (Fig. 2) clearly

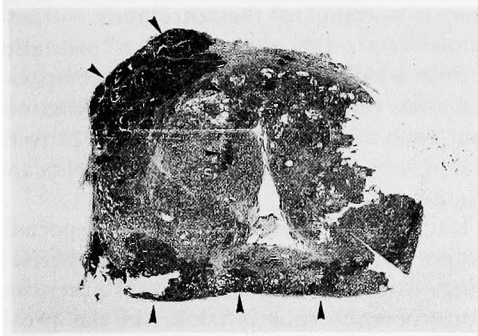


Fig. 3. Gross section of case 1. The dark area (arrowhead) is the cancerous focus. Most tissues in the inner zone is BPH, and the area indicated by the large arrowhead corresponds to BPH nodule in Fig. 2.

depicted the inner and outer zones, and a part of the border line between the inner and outer zone was found to be destroyed. Several areas of the inner zone also had a slightly higher intensity than other parts of the inner zone, just like a BPH nodule. The area of pathologically revealed cancer in the outer zone (Fig. 3) had a low intensity on T2 weighted image but had almost the same intensity as the normal outer zone on T1 weighted image. However, the high intensity areas in the outer zone on T2 weighted image *in vitro* MRI were identified as nonmalignant conditions, and the low intensity areas were either cancer or fibrotic tissue. However, there was no significant difference in signal intensity in the internal zone between cancerous and nonmalignant conditions. The area where cancer invaded into the internal zone corresponded to the area of the destroyed border line.

In vitro MRI of a stage B2 (T2N0M0) case (case 2) was studied by using a head coil. The T1 weighted image did not show any nodular image but showed a heterogeneous image. Cancer was found in both the inner and outer zones (Fig. 4, 5). The inner zone of the specimen was mainly composed of cancer, and fibromuscular tissue, and the T2 weighted image (Fig. 6) clearly showed such a structure. Cancer in the outer zone had low intensity, and in the inner zone it showed only a slightly higher intensity than the muscle.

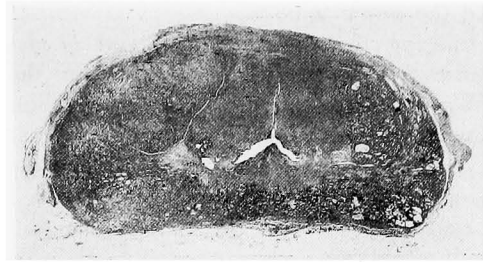


Fig. 4. Gross section of case 2.

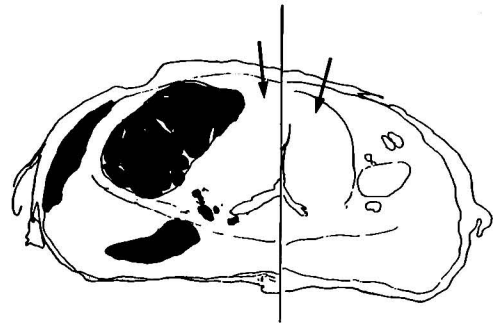


Fig. 5. Schema of cancer distribution of Fig. 4. The black area corresponds to the cancerous focus, and the arrow indicates fibromuscular tissue. The remaining area is mostly occupied by normal prostate tissue.

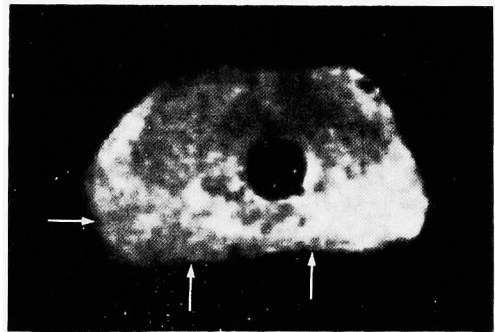


Fig. 6. T2 weighted image of case 2. Three low intensity areas in the outer zone (arrow) are suggested to be cancer foci, and in the inner zone cancer has only a slightly higher intensity than the muscle.

Almost all of these findings were consistent with the *in vivo* MRI findings.

All patients who did not undergo radical operation and whose axial T2 weighted MRI were examined had either a low intensity area or partial or total destruction of the border line between the inner

and the outer zone.

Judging from these *in vitro* and *in vivo* studies, we conclude that cancer in the outer zone can be observed as a lesion showing lower intensity than the rest of the outer zone, and does not appear so clear in the inner zone. The destroyed border line between the outer zone and the internal zone corresponded to the area where cancer invaded into the internal zone. These findings were also recognized on *in vivo* MRI⁴⁾.

The T1 and T2 values were measured in 4 specimens, but no significant differences could be demonstrated between cancer and other parts of the prostate.

DISCUSSION

MRI is a new imaging modality and it is hoped that the superior soft tissue contrast of MRI over CT allows more accurate delineation of neoplastic extension.

Zonal anatomy of the prostate was depicted by MRI at a high magnetic field. According to the published reports^{5,6)}, the anterior fibromuscular tissue of the normal prostate, the glandular tissue comprising the central zone of the prostate, and the glandular tissue of the peripheral zone of the prostate can be differentiated in intensity on the T2 weighted image. However, recognition of the normal zonal anatomy of the prostate was impossible in the studies at a low magnetic field strength. The importance of recognition of the peripheral zone that might represent cancer in this region was also pointed out in these reports. We previously reported⁴⁾ that the outer zone was differentiated from the inner zone and that the outer zone showed a high signal intensity. Phillips et al.⁷⁾ suggested that the peripheral zone had a high intensity due to a higher water content, less protein content, and less fibromuscular stroma.

Although most investigators⁸⁻¹¹⁾ found it difficult to distinguish carcinoma from benign hyperplasia. Steyn et al.¹²⁾ suggested that carcinoma showed an irregular outline and that its field was nonhomogeneous. Larkin¹³⁾ pointed out that a focal nodule of prolonged T1 and T2 relaxation

time is specific to the carcinoma. Herman¹⁴⁾ et al. did a biopsy of a prostatic nodule which was hypointense in comparison with the surrounding parenchyma on spin echo 2000/28 scan only, and proved that it was poorly differentiated adenocarcinoma.

Ling¹⁵⁾ and Buonocore¹¹⁾ have reported studies similar to ours, on *in vitro* MRI. Ling observed a signal of lower intensity from the cancerous left lobe of the prostate, but he concluded that MRI could not distinguish between BPH and cancer. Carrol et al.¹⁶⁾ found that 8 of their 12 prostatic cancer cases (67%) were hypointense to the remainder of the peripheral zone. They were unable to identify tumor prospectively in four cases (33%), but in only one of these four cases were they unable to identify the tumor prospectively and retrospectively. Phillips et al.¹⁷⁾ interpreted the presence of a low intensity area in the outer zone as a sign of extracapsular invasion. As mentioned above, some authors suggested some relation between low intensity areas in the outer zone and the prostatic cancer, but no one proved the direct relation between the low intensity areas and the cancer areas, pathologically.

Our comparative study between *in vitro* MRI and pathological specimens precisely suggested that the carcinoma in the peripheral zone showed a lower intensity signal than that in other parts of the outer zone. This difference may be due to the volume of glandular secretion between normal glands and cancer.

In our experience of *in vitro* and *in vivo* MRI on 6 patients who underwent total prostatectomy, cancer foci in the inner zone were not always detected, but those in the outer zone could be observed on the T2 weighted images. In addition, when cancer invaded into the inner zone, partial or total disappearance of the border line between the inner and the outer zones indicated the presence of the cancer. Although small prostatic cancer foci had a similar appearance on *in vivo* MRI, an enlarged lesion showed the destruction of the border line between the internal

and the outer zone. A lower intensity area in the outer zone or a partial or total disappearance of the border line was also noted on T2 weighted axial images in all other patients who did not undergo radical operations.

There was no significant difference in the T1 or T2 values of the 4 specimens between cancerous and noncancerous parts of the specimens. Increased T1 and T2 values are attributed to increased free water, and these characteristics may be seen in other medical disorders such as edema, infection, benign tumors, malignant tumors and so on. Therefore, T1 and T2 values are thought to be of little clinical importance.

In the internal zone, BPH nodules and cancer foci could not be distinguished by the difference in the image intensity, but considering the finding that most cancers originate in the peripheral zone¹⁸⁾, minor changes in this zone should not be overlooked.

In conclusion, we propose the following criteria for diagnosing early localized prostatic cancer on MRI:

- 1) A focal area of low intensity signal image in the outer zone with high intensity on T2 weighted image, because carcinoma almost always occurs from the peripheral zone¹⁸⁾, and
- 2) a partial or total destruction of the border line between the inner and outer zones⁴⁾.

Our data suggest that MRI is a promising method not only for staging prostatic cancer but also for detecting early prostatic cancer, and that MRI should be used as a primary noninvasive imaging modality for preoperative local staging.

Carrol et al.¹⁵⁾ also concluded that high field strength MR imaging may be of predictive value in the differential diagnosing of prostatic abnormality when their location can be demonstrated. Although MRI may not be practical for use as a screening procedure because of its high cost, it seems to be useful for detecting early prostatic cancer.

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和文抄録

前立腺癌の MRI: *In Vivo* および *In Vitro* MRI と病理標本の比較

京都大学医学部泌尿器科学教室 (主任: 吉田 修教授)

西村 一男, 飛田 収一, 岡田謙一郎, 吉田 修

京都大学医学部核医学教室 (主任: 小西淳二教授)

西 村 一 雅

23例の前立腺癌の患者に対し MRI を施行した。うち6例に前立腺全摘術を施行、そのうち5例は摘出標本の MRI を施行し、摘出標本の全割切片を作成し、比較検討した。正常の前立腺は内、外腺に分かれて描出され、両者の間には信号の無い境界線が存在する。さらに正常の前立腺外腺は T2 強調画像において、内腺より high intensity を示したが、外腺内の癌の部分は正常の外腺より low intensity を示した。

また、外腺に発生した癌が内腺に浸潤していく部分に一致して内、外腺の境界線の一部もしくは全部の消失が認められた。これらの所見は *in vivo* の MRI でも認められた。

MRI は、前立腺癌の local staging に関し臨床的価値があると思われた。

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