

# Assessment of Tumor Extension and Improved Localization for Planning and Nerve Sparing Radical Prostatectomy

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## Introduction

Prostate cancer (PCa) is the most common malignancy in men and according to the update of the National Cancer Institute in 2005, the incidence of this malignancy in the United States of America is higher than for female breast cancer (2004: 165.3 PCa per 100.000 men; 126.4 breast cancer per 100.000 women). Also, with the widespread introduction of PSA testing a shift towards detection of PCa at an early stage of disease can be observed. The potential of magnetic resonance imaging (MRI) for imaging PCa was already recognized and evaluated in the beginning of the wide introduction of MRI into clinical practice in the early 80's. Until recently, the combination of T2-weighted Turbo Spin Echo (T2w TSE) sequences and the application of an endorectal coil had still been considered as state-of-the-art for local tumor staging, in particular for magnetic field strengths up to 1.5 Tesla, whilst the

main indication for MRI of the prostate in the daily clinical work-up had remained tumor staging for assignment of best therapy. However, clinical demands have changed dramatically during the last decade; while prostate-specific antigen (PSA) testing has significantly reduced the amount of advanced (T4/T3; N+, M+ stages) PCa at the time point of diagnosis, the refinement of surgical and radiotherapy treatment procedures like robot-assisted nerve sparing radical prostatectomy and intensity modulated radiotherapy have increased the demand for a dedicated and accurate imaging modality to provide all relevant information about extension and localisation of prostate cancer. Of course, it has been recognised since the early days of prostate MRI that due to hyperplasia of the central gland, prostatitis and bleedings (e.g. caused by former biopsies) the diagnostic accuracy of T2w TSE MRI can be clearly restricted for

such a purpose. Therefore it seems to be only logical to include information provided by metabolic (MR spectroscopic imaging; MRSI) and functional imaging (diffusion-weighted imaging; syngo DWI and T1-weighted dynamic contrast enhanced MRI; T1w DCE) to improve the diagnostic performance of MRI. With the introduction of the 3T MR scanner and associated increase in signal-to-noise (SNR) there is now the potential to acquire all this information without the use of an endorectal coil. Based on literature data, the application of an endorectal coil at 3T will increase the sensitivity for the detection of tumor penetration of the capsule; nevertheless, for tumor localization within the gland e.g. for planning of radiotherapy or MRI-guided biopsies and also for follow-up, deformation of the prostate introduced by the endorectal coil can be disadvantageous. The potential of state-of-the-art MRI at

3T without endorectal coil is presented in this case report article. In both shown cases, MRI was able to improve therapy planning and the surgical outcome clearly. To improve the image quality especially of the diffusion-weighted imaging (syngo DWI), after a digital rectal examination 50 to 100 ml ultrasound gel was administered per rectum in both cases. Sequence parameters for the shown MR examinations were:

## 1. T2-weighted MRI Turbo Spin Echo (TSE) sequences:

### Transversal T2w TSE:

TR 6330 ms, TE 101 ms, PAT factor 2 (syngo GRAPPA), FOV 200 x 200 mm, matrix 310 x 320, slice thickness 3 mm, 3 averages, acquisition time 3:04 min.

### Coronal T2w TSE:

TR 4440 ms, TE 101 ms, PAT factor 2 (syngo GRAPPA), FOV 200 x 200 mm, matrix 310 x 320, slice thickness 3 mm, 2 averages, acquisition time 3:44 min.

### Sagittal T2w TSE:

TR 5000 ms, TE 101 ms, PAT factor 2 (syngo GRAPPA), FOV 200 x 200 mm, matrix 310 x 320, slice thickness 3 mm, 2 averages, acquisition time 2:40 min.

## 2. Diffusion-weighted imaging (syngo DWI):

### Single shot echo planar imaging (EPI):

TR 3800 ms, TE 70 ms, PAT factor 2 (syngo GRAPPA), SPAIR fat suppression technique, FOV 221 x 260 mm, matrix 102 x 160, 3 scan trace, ADC-mapping (Inline), **b-values:** 0 / 100 / 400 / 800 s/mm<sup>2</sup>, slice thickness 3.6 mm, 6 averages, acquisition time 2:40 min.

## 3. 3D MR spectroscopic imaging:

TR 750 ms, TE 145 ms, voxel size (interpolated) 0.5 x 0.5 x 1.1 cm, averages 8, Hamming filter, spectral lipid and water suppression, acquisition time 9:14 min.

**4. 3D dynamic contrast enhanced T1-weighted imaging:**  
 syngo TWIST (GRE with echo sharing):  
 TR 3.5 ms, TE 1.4 ms, PAT factor 2, no fat suppression, slice thickness 3.6 mm, FOV 260 x 260 mm, matrix 144 x 192,

1 average, 70 measurements, acquisition time for one data set was 04:58 min; contrast media was injected via a cubital vein in a standardized flow and dosage with the start of the first measurement (Magnevist, Bayer Schering, Germany).

→ Visit [www.siemens.com/magnetom-world](http://www.siemens.com/magnetom-world) for practical information on MR spectroscopic imaging of the prostate in clinical routine.

- Starting on page 64 of the *Operator Manual – Spectroscopy* you'll find
  - positioning of the patient and coil
  - planning the VOI
  - measurement and
  - examples of spectra.

The manual also includes the evaluation of spectroscopic data with the syngo Spectroscopy task card and provides detailed information on the workflow of a typical 1H MRS examination in the head and breast (syngo GRACE).

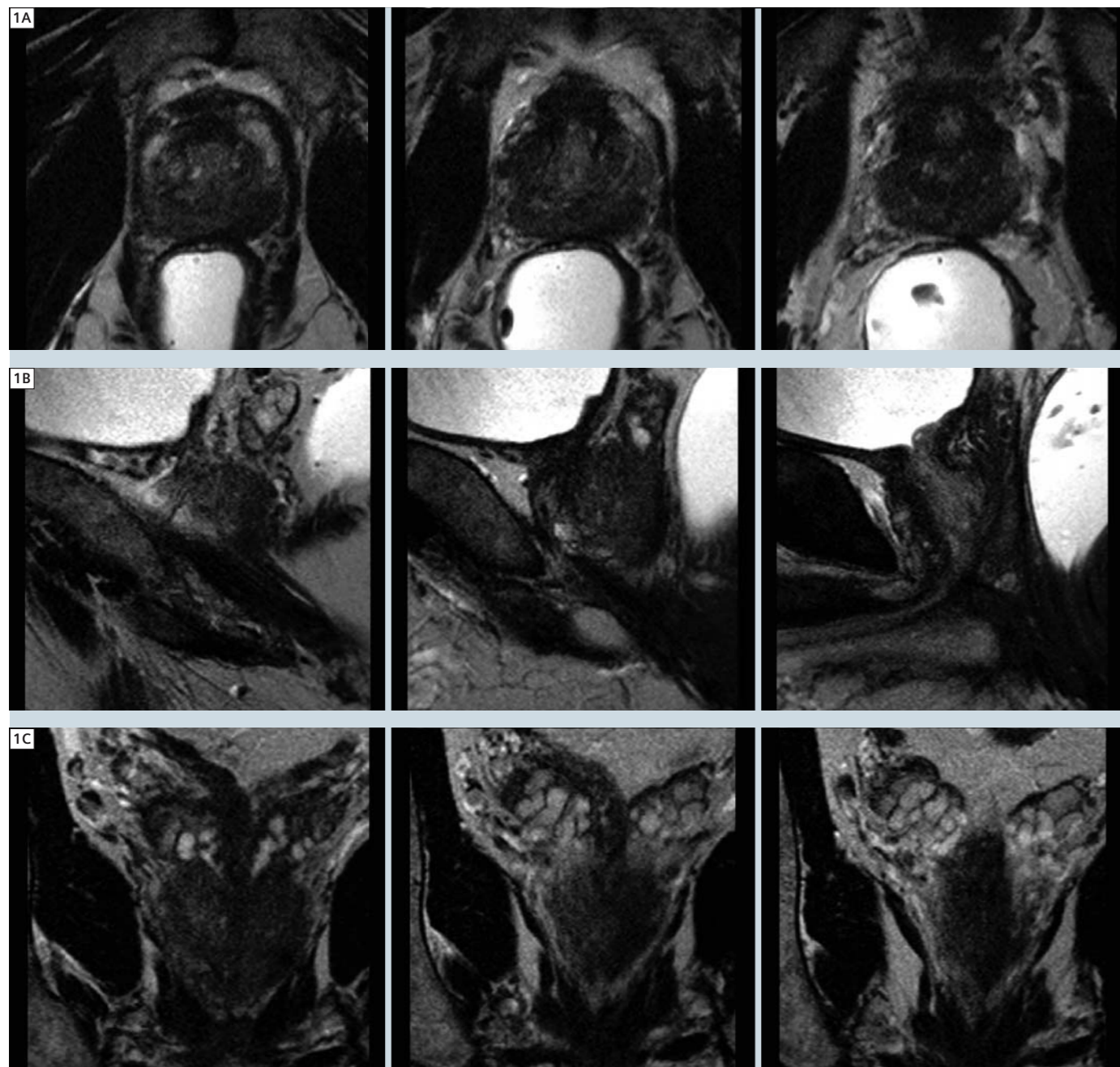
At [www.siemens.com/magnteom-world](http://www.siemens.com/magnteom-world) you can download the manuals in German and English free-of-charge.

**Case 1**  
**Patient with stage T3a prostate cancer**

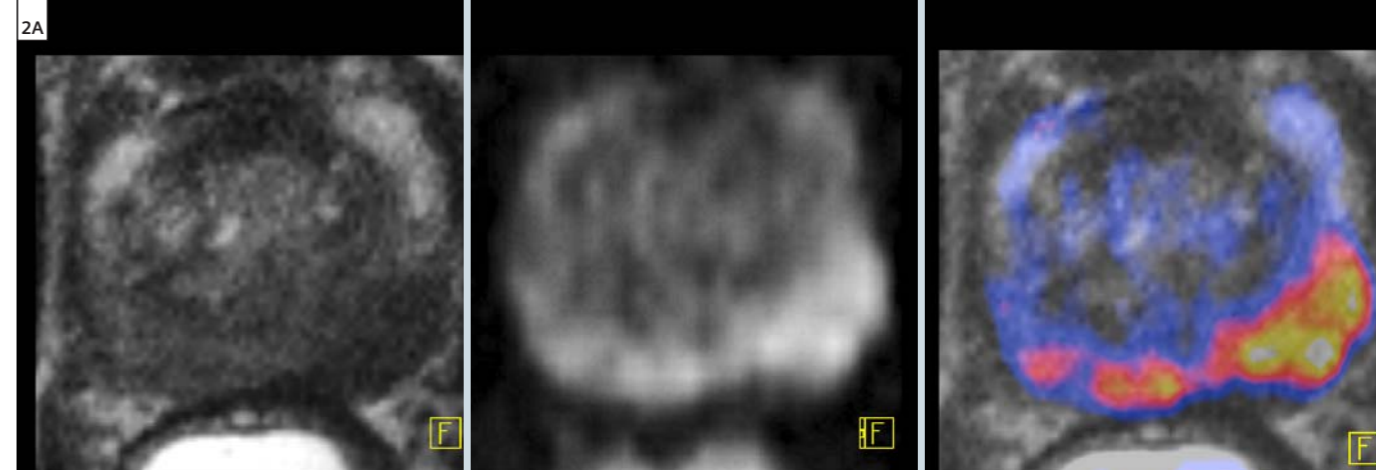
This 61-year-old patient with biopsy proven prostate cancer and an initial total PSA level of 5.1 ng/ml was referred

to our MRI unit one day before planned nerve sparing radical prostatectomy. MRI revealed a tumor with broad contact

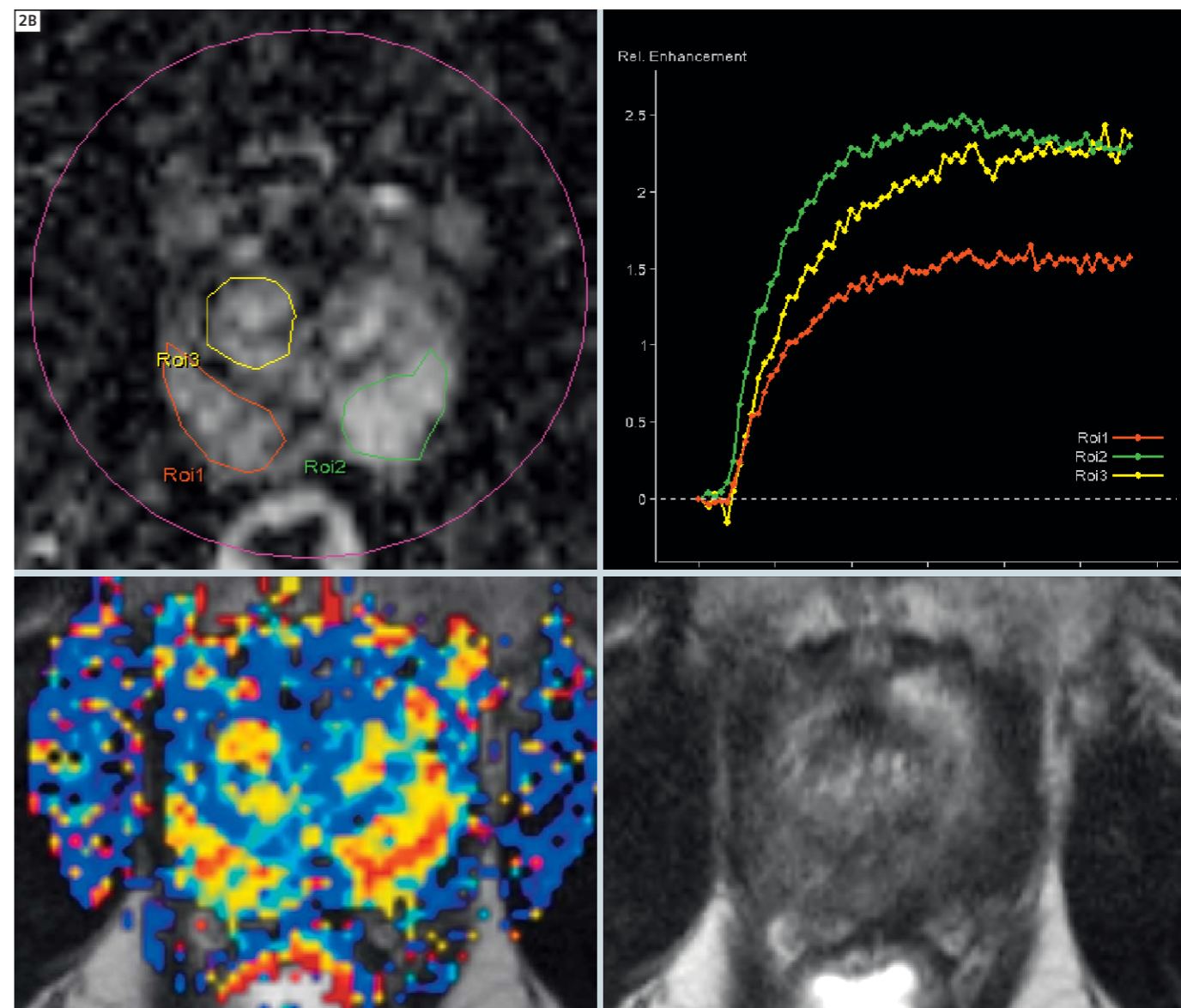
to the left dorsal capsule with main localization in the apico-medial peripheral zone and extension to the base.



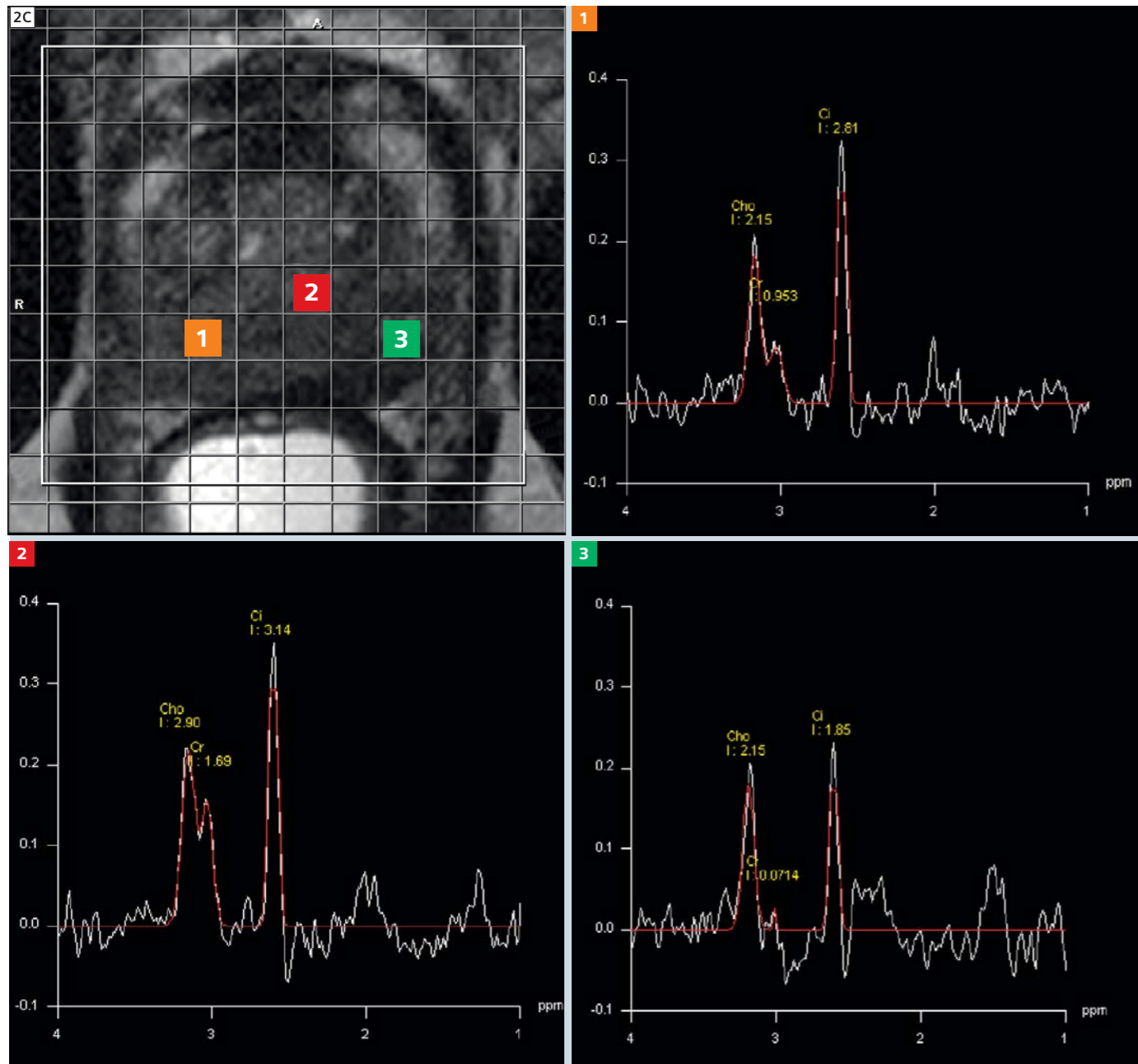
**1** Exemplary chosen T2-weighted TSE images demonstrating the extent of the tumor suspicious findings (A transversal, B sagittal, C coronal).



**2A** This figures show the clear restriction of the water diffusion within the tumorous areas. Left: T2-weighted TSE image, middle: original high b-value image ( $b = 800 \text{ s/mm}^2$ ), right: overlay of *syngo* DWI and T2-weighted TSE image, showing perfect match, confirming the extension of the tumor.



**2B** DCE T1-weighted image demonstrating the difference between the cancer and normal prostate tissue. Left: T1-weighted DCE image subtracted from a native mask image at the time point of the maximum peak of the signal-intensity-time curves (middle) within the tumor tissue. While standardized parameter maps do show only a slight side difference (Kep right upper image; right lower image T2-weighted reference), the signal-intensity-time curves are highly suspicious and correlate clearly with the morphologic changes on T2-weighted image.



**2C** Exemplary chosen spectra from the base of the prostate, demonstrating the widespread tumor infiltration. In all voxels, a clear increase of the (Choline + Creatine) / Citrate ratio can be observed.

No seminal vessel infiltration and suspicious lymph nodes were found. Despite the lack of a clear extension beyond the capsule, the finding was highly suspicious for a micro penetration of the capsule, potentially negating a bilateral nerve sparing. The strong suspicion of a T3a stage was confirmed during the radical prostatectomy by an instant-

aneous section. To ensure oncological resection of the tumor, it was not possible to preserve the left nerve bundle. According to the MRI findings, the surgeons could spare the right nerve bundle. The prostate cancer was staged as pT3a pN0 (0/15) cM0 R0, Gleason Score 3 + 4 = 7.



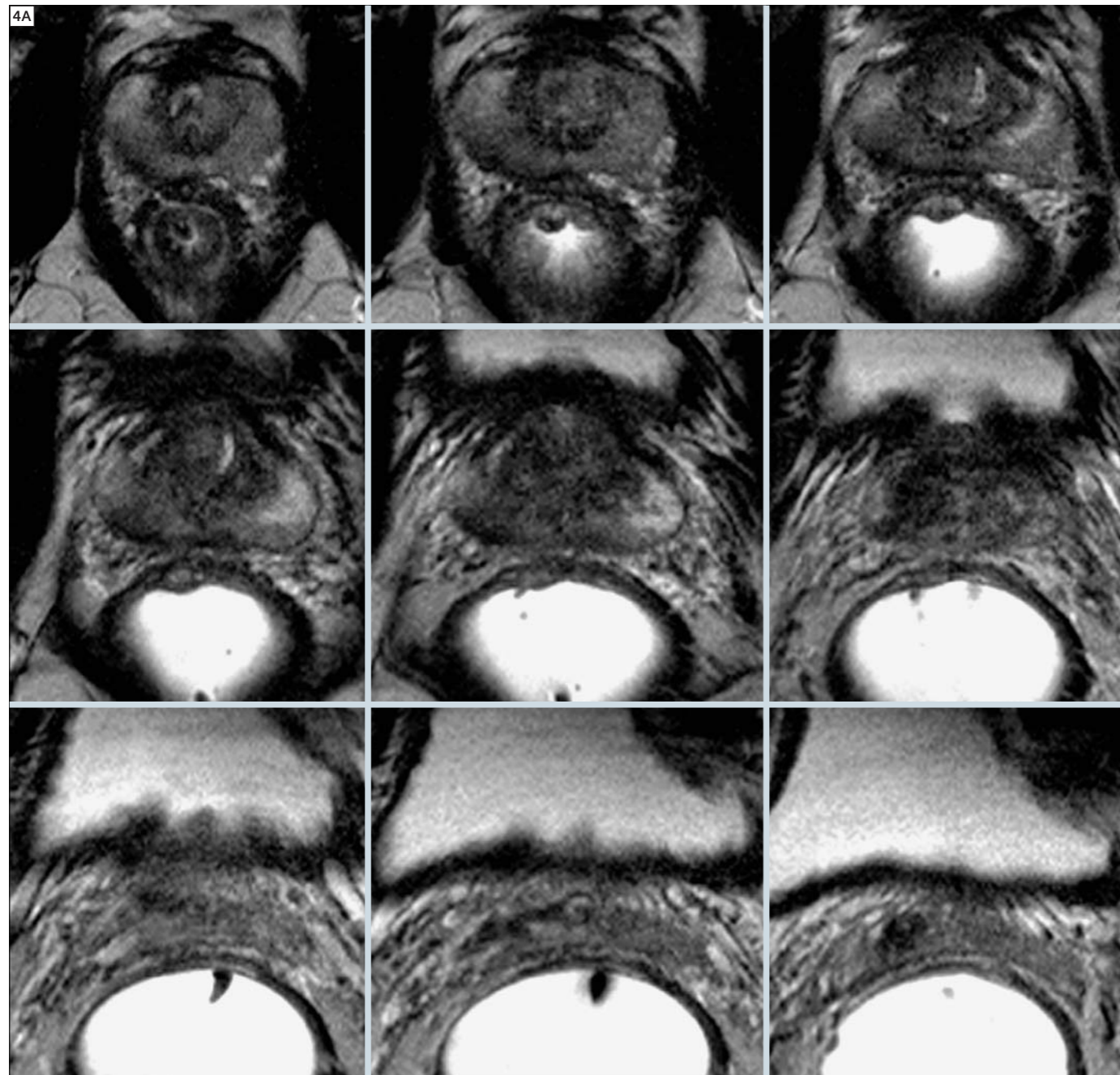
**3** A: Macroscopic prostatectomy specimen before fixation, B: HE stained histopathology with marked extension of all tumor foci (blue line). A high concordance between MR findings and histopathology is obvious.

**Case 2**  
**Patient with stage T3b prostate cancer**

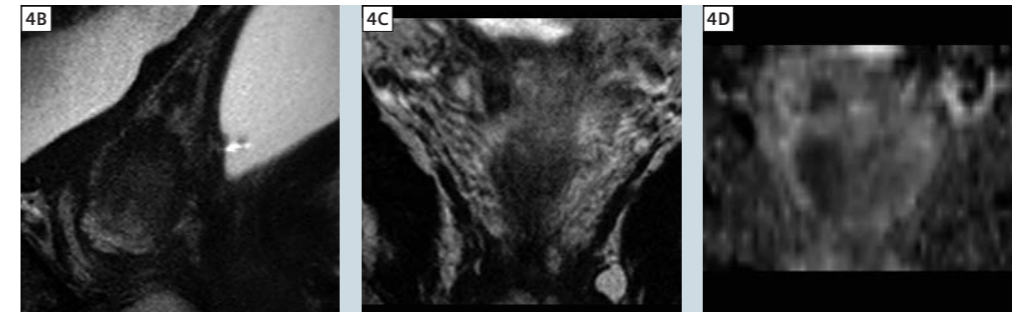
This 63-year-old patient with biopsy-proven prostate cancer and a total PSA level of 7.51 ng/ml at the time point of surgery was referred to our MRI unit one day before planned nerve sparing radical prostatectomy. The medical history of

the patient revealed a urothelium carcinoma (initial diagnosis made 6 years ago) and approx. one month before the planed radical prostatectomy, a resection of suspicious pulmonary findings was performed but no malignancy was

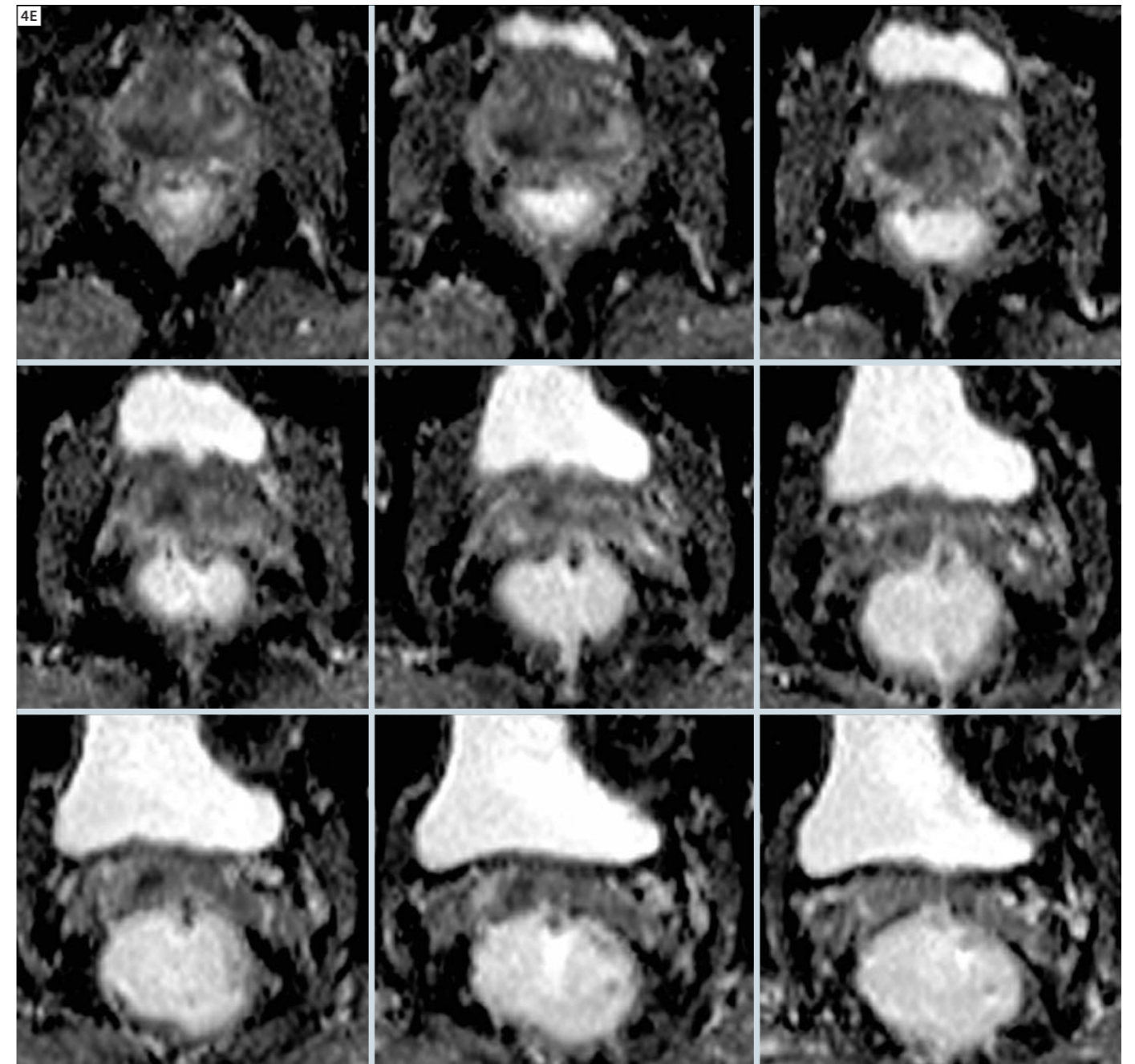
found. The histopathology revealed heterotopic ossifications. MRI revealed a tumor of the right dorsal gland within the peripheral zone with broad contact to the capsule. Additionally, in the right seminal vesicle,



**4A** Exemplary chosen T2-weighted images (transversal) demonstrating the extent of the tumor suspicious findings. **D, E:** Corresponding ADC-maps, demonstrating the clear water diffusibility restriction also in the suspicious area within the right seminal vesicle.



**4B-D** Exemplary chosen T2-weighted images (**B** sagittal, **C** coronal) demonstrating the extent of the tumor suspicious findings. **D:** Corresponding ADC-maps, demonstrating the clear water diffusibility restriction also in the suspicious area within the right seminal vesicle.

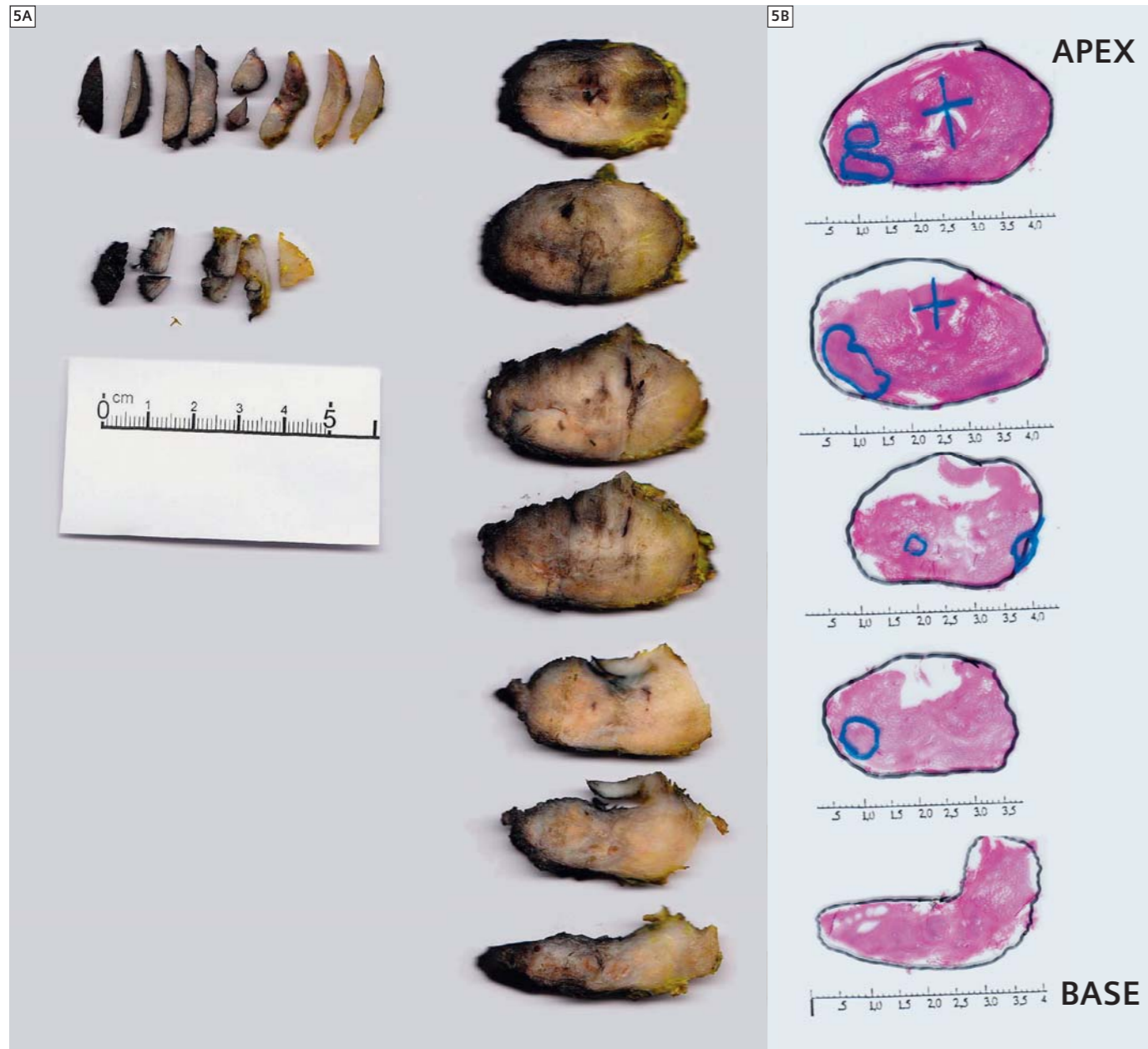


**4E** Corresponding ADC-maps, demonstrating the clear water diffusibility restriction also in the suspicious area within the right seminal vesicle.

a T2-weighted hypointense and nodular configured area was detected. In combination with the clear restriction of the water diffusion, this finding was categorized as tumor and therefore a stage T3b was assumed. In agreement with

MRI findings, the instantaneous section found capsule penetration with infiltration of the nerve bundles as well as extension towards the right seminal vessel and therefore no nerve sparing prostatectomy could be achieved

(R0 resection). However, lymphadenectomy found positive pelvic lymph nodes. The prostate cancer was staged as pT3b pN1 (3/14) cMx, R0, L0, V0, Gleason Score 4 + 3 = 7.



**5** A: Macroscopic prostatectomy specimen before fixation, B: HE stained histopathology with marked extension of all tumor foci (blue line). A high concordance between MR findings and histopathology is obvious. The specimen of the seminal vessels and the lymph nodes are not shown in this stage pT3b pN1 case.

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