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Tumorsize dependent detection rate of endorectal MRI of prostate cancer—A histopathologic correlation with whole-mount sections in 70 patients with prostate cancer

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ABSTRACT

Purpose: To evaluate the value of T2w endorectal MRI (eMRI) for correct detection of tumor foci within the prostate regarding tumor size.
Materials and Methods: 70 patients with histologically proven prostate cancer were examined with T2w eMRI before radical prostatectomy at a 1.5 T scanner. For evaluation of eMRI, two radiologists evaluated each tumor focus within the gland. After radical prostatectomy, the prostates were prepared as whole-mount sections, according to transversal T2w eMRI. For each slice, tumor surroundings were marked and compared with eMRI. Based on whole-mount section, 315 slices were evaluated and 533 tumor lesions were documented.
Results: Based on the T2w eMRI, 213 tumor lesions were described. In 137/213, histology could prove these lesions. EMRI was able to visualize 0/56 lesions with a maximum size of <0.3 cm (detection rate 0%), between 0.3 and 0.5 cm 4/116 (3%), between 1 and 0.5 cm 22/169 (13%), between 2 and 1 cm 61/136 (45%) and for >2 cm 50/56 (89%). False positive eMRI findings were: <0.3 cm $n = 0$, 0.5–0.3 cm $n = 12$, 0.5–1 cm $n = 34$, 1–2 cm $n = 28$ and >2 cm $n = 2$.
Conclusion: T2w eMRI cannot exclude prostate cancer with lesions smaller 10 mm and 0.4 cm^3 respectively. The detection rate for lesions more than 20 mm (1.6 cm^3) is to be considered as high.

1. Introduction

Prostate cancer (PCa) is the most common malignancy in men and according to the American Cancer Society the estimated new cases in the United States of America will be 192,280 men in 2009; the estimated deaths will be 27,360 [1]. The potential of MRI for imaging PCa was already recognized and evaluated in the beginning of the wide introduction of MRI into clinical practice in the early eighties [2]. Until today, the combination of T2 weighted turbo-spin-echo (T2w TSE) sequences and the application of an endorectal coil (eMRI) has to be considered as state-of-the-art for local tumor staging [3–5], in particular for high magnetic field strengths up to 3 T. At present the main indication for eMRI of the prostate in the clinical work-up is tumor staging for assignment of best therapy. But clinical demands changed during the last two decades. While PSA testing has significantly reduced the amount of advanced PCa (T4/T3; N+, M+ stages) at the time point of diagnosis, there has been also an increasing number of negative prostate biopsies [6]. Also the increased fraction of cancer with low-risk profiles (T1a-b tumors with a Gleason-scores of 5 and below in combination with a total PSA-level of <10 ng/ml) as well as clinical insignificant PCa in old men with unclear benefit from radical prostatectomy/radiotherapy introduced alternative therapy regimes, e.g. active surveillance or (focal) tumor ablation [5,7]. MRI as method with excellent soft tissue contrast for detecting non-organ confined tumors is also a prerequisite for being a useful tool for biopsy-planning, either ultrasound- or MRI-guided [8,9].

Additional information provided by metabolic (MR-spectroscopic imaging; MRS) and functional imaging (diffusion-weighted imaging; DWI and T1w dynamic-contrast media enhanced MRI; T1w DCE) for improving the diagnostic performance of MRI has been obtained in the meantime [10,11]. However, it is still inevitable to use T2w TSE MRI as a robust, fast and as easily repeatable diagnostic modality.

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Data about T2w TSE eMRI to identify suspicious lesions within the prostatic gland regarding exact tumor size are rare. Most of the published data do lack of exact match with histopathology (no whole-mount sections), were focussed on local tumor staging or evaluating new imaging techniques like DWI. Older studies focussed on low-filed MRI and/or low-resolution MRI. It is an important point for the further clinical development of (multimodal) MRI to evaluate the detection rate of state-of-the-art T2w TSE eMRI in special regards towards the upcoming requirements: detection and monitoring of suspicious lesions within the gland [5,12].

Therefore, purpose of this study was to evaluate the detection rate of tumor foci of prostate cancer by T2w TSE eMRI at 1.5 T regarding tumor size.

2. Materials and methods

2.1. Patients

In total, 70 patients with biopsy-proven PCa underwent eMRI before nerve sparing radical prostatectomy (RPx) in our university hospital. The patients were recruited consecutively based on our prospectively planned study design. All patients were informed in detail about the purpose and procedure of the examination. Conduction of eMRI, reporting and informed consent was according standard clinical procedures and in accordance with the Declaration of Helsinki [13]. Time interval between biopsy and eMRI was at least three weeks. Mean age ± standard deviation at the time of eMRI was 62.5 ± 5.7 years (range 47–79 years; median was 63 years), time interval between eMRI and RPx was 7.6 ± 20.7 days (range 0–131 days; median was 1 day), total PSA-levels before RPx were 9.23 ± 4.87 ng/ml (range 0.9–26.6 ng/ml; median was 7.95 ng/ml). Based on eMRI and assumption of an elliptical shape, estimated prostate volume was 36.4 ± 16.3 cm^3 (range 14.3–96.2 cm^3; median was 34 cm^3). No former radiation therapy and/nor hormone deprivation was reported in our patient cohort.

2.2. MRI—examination and reporting

Exclusion criteria included general contraindications for MRI. Patient cohort was limited to surgical scheduled patients referred from the Department of Urology. EMRI was conducted with a standardized protocoll at a single MR scanner at 1.5 T (Magnetom Sonata; Siemens Medical Solutions, Erlangen, Germany). For signal reception, a combination of the manufacturer standard multi-channel body and integrated spine phased array coils with an endorectal coil (Medrad Inc., Indianola, PA, USA) was used. Before insertion of the endorectal coil, a digital rectal examination was performed. To reduce potential bowel motion, body-weight adjusted 20–40 mg butyl-scopolamine (Buscopan®, Boehringer Ingelheim, Germany) was administered intravenously in fractions (one fraction before insertion of the coil and the other before application of the T2w TSE sequences) in patients with no contraindications. After insertion, the endorectal coil was inflated with 40–60 ml air. EMRI comprised T2w half-fourier acquisition turbo-spin-echo (HASTE) sequences for prostate localization and planning of slice angulations of the T2w TSE sequences. Transversal T2w TSE slice orientation was defined perpendicular towards the rectum wall to assure best standardization of slice orientation in T2w imaging and for the preparation of the whole-mount sections. For lymph node staging and detection of haemorrhage, a 3D T1w gradient echo sequence (fast low angle shot; FLASH) was used. Sequence parameters for the axial/coronal T2w TSE sequences were: TR 9820/7720 [ms], TE 121/121 [ms], FoV (169 × 200)/(169 × 200) [mm^2], Matrix size (216 × 512)/(216 × 512) [Px^2], number of slices 30/24 [n], slice thickness 3/3 [mm], averages 3/3 [n], resulting acquisition time (TA) 7:22/7:20 [min:sec]; the resulting voxel size was (0.8 × 0.4 × 3) [mm^3] for transversal and coronal T2w TSE, respectively. Turbo factor was 23 each and no parallel imaging techniques were applied. To reduce the total rooming time, the numbers of slices could be reduced depending on prostate volume and the conducting technicians were allowed to reduce the resulting TR down to 5000 [ms]. Voxel sizes and TE were fixed in all cases.

For data evaluation, a standardized evaluation sheet was used. Two radiologists (M.L., H.S.) with 10 and 5 years experience in prostate imaging documented in consensus each suspicious area within the prostatic gland including configuration and extension (maximal transversal diameter was reported, too) and marked areas of capsule penetration and infiltration of the seminal vessels. The two radiologists were blinded to clinical data, including results of histopathology. They were aware of the fact that all patients had biopsy-proven prostate cancer.

Criteria for rating of T2w lesions as tumor foci in the peripheral zone were homogeneous hypointense signal intensity with tuberose and asymmetric appearance. Stringy configured T2w hypointense areas of the peripheral zone, tapering the central zone in a triangular shape were rated as signs of prostatitis. In the zentral zone toumor foci were interpreted as areas with homogenious low-signal intensity, ill-defined margins and lack of capsule. Irregular shape of the prostatic capsule was rated as non-organ-defined PCa.

2.3. Histopathology—preparation, reporting and correlation with MRI

After RPx and fixation, the specimens were laminated in 3 mm thick slices from base to apex in a comparable orientation to T2w transversal eMRI. After documentation of these macroscopic specimens, every second slice of the specimens was processed as a whole-mount section. Documentation and reporting for the correlation with MRI was based on hematoxyline-eosine (HE) stained sections and was conducted by a single, experienced (>7 years) pathologist. All tumor foci were outlined on the whole-mount sections and areas of penetration of the capsule were marked. After digitalization of all in this manner prepared HE stained slices, a side-by-side correlation with the standardized eMRI-reporting sheet was conducted in a first step. For lesions with unclear correlation between eMRI and histopathology, in cases of false negative eMRI reports and offset between whole-mount sections and eMRI (introduced by mismatch of the transversal orientated slices, false angulations of whole-mount sections/T2w transversal TSE MRI or large deformation by the endorectal coil), a further reporting of the eMRI with knowledge of the whole-mount section was performed. Shrinkage of prostates by the histopathologic preparation after RPx is well known and was present in all cases, but did not interfere with data correlation or required an additional reading of eMRI data. Based on histopathology, the lesions were classified according to their maximal transversal diameter in the following five categories: lesions <0.3 cm, 0.3–0.5 cm, <1 cm, 1–2 cm and >2 cm. For false positive lesions on eMRI, the maximal diameter on the original transversal T2w TSE images was identified and the lesions were classified accordingly. Clusters of small tumor foci with bleeding and corresponding larger lesions in the eMRI report were rated as one large focus with the maximum diameter of the cluster to avoid false negative ratings for eMRI (compare Figs. 1 and 2).

2.4. Statistical analysis

For statistical analysis the Pearson correlation index was calculated (JMP, The SAS Institute Inc., NC, Cary, USA). For evaluation of SI changes, an unpaired two-sided Student's t-test with $p < 0.05$ as significance level was used.