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ORIGINAL ARTICLE / *Genitourinary imaging*

## Comparison of semi-automated and manual methods to measure the volume of prostate cancer on magnetic resonance imaging

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### KEYWORDS

Prostate neoplasms;  
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imaging (MRI);  
Index lesion;  
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Comparative studies

### Abstract

**Purpose:** The purpose of this study was to determine the accuracy of manual semi-automated and volumetric measurements to assess prostate cancer volume on multiparametric magnetic resonance imaging (MP-MRI) using whole-mount histopathology for validation.

**Materials and methods:** We evaluated 30 consecutive men (median age, 65.7 years; interquartile range [IQR], 61.5–70.9 years) with a median prostatic specific antigen of 8.5 ng/dL (IQR, 5.5–10.5 ng/dL), who underwent MP-MRI before radical prostatectomy. Index tumor volume

**Abbreviations:** MP-MRI, multiparametric MRI; MTD, maximal tumor diameter; MREV, magnetic resonance ellipsoid volume; MROV, magnetic resonance OsiriX<sup>®</sup> volume; HV, histologic volume; TV, tumor volume; R1, reader 1; R2, reader 2; ROI, region of interest.

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was determined prospectively and independently on the basis of MRI and whole-mount section volumetric assessment using the maximum histologic diameter (MHD) and the histologic volume (HV). The MRI index tumor volume was determined by two independent radiologists using a single measurement of the maximum tumor dimension (MTD), a simplified MR ellipsoid volume (MREV) calculation and a MR region of interest volume (MROV) segmentation displayed by a commercially available OsiriX<sup>®</sup>. MTD was compared to MHD, whereas MREV and MROV were compared to HV.

**Results:** Thirty index lesions (median HV, 1.514 cm<sup>3</sup>; IQR, 0.05–3.780 cm<sup>3</sup>) were analyzed. The MREV, MROV and HD were significantly correlated with each other ( $r > 0.5$ ). Inter-observer agreement for measurements was good for each method ( $r > 0.780$ ). The MTD was the best predictor of maximum histologic diameter ( $r = 0.980$  and  $0.791$ ) and had an excellent inter-variability correlation ( $P < 0.0001$ ).

**Conclusion:** Prostate cancer histologic volume can be assessed using MREV or MROV with a good accuracy and low inter-observer variability. MTD has the lowest inter-observer variability and provides best degrees of correlation with MHD. MTD should be used on MRI for selecting and following patients for active surveillance and staging before focal treatment of prostate cancer.

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There is increasing interest in active surveillance and minimally invasive focal therapies for patients with prostate cancer. In this regard, image-guided tumor ablation has been developed to avoid morbidities associated with whole gland therapy. Tumor volume (TV) is a well-known prognostic factor of prostate cancer [1] and the definition of index lesion volume is important for appropriate decision making, especially for image-guided focal treatment [2] or in case of active surveillance [3]. Multiparametric magnetic resonance imaging (MP-MRI) is the modality of choice for detection and localization of prostate cancer foci [4–8]. However, little has been published on MP-MRI accuracy in determining prostate cancer volume, especially at 3T. There is insufficient evidence and no agreed consensus concerning which method of measurement should be used to determine tumor volume.

The purpose of our study was to determine the accuracy of manual semi-automated and volumetric measurements to assess prostate cancer volume on MP-MRI using whole-mount histopathology for validation.

## Patients and methods

### Patients

This is a retrospective analysis of a prospectively maintained database. We evaluated 30 consecutive men (median age, 65.7 years; interquartile range [IQR], 61.5–70.9 years) with a median prostatic specific antigen of 8.5 ng/dL (IQR, 5.5–10.5 ng/dL), who underwent MP-MRI before radical prostatectomy.

The current study was approved by the institutional review board and informed consent was obtained from all participants.

### MP-MRI protocol

MP-MRI examinations were performed on a 3-T MR scanner (Magnetom Skyra<sup>®</sup>, Siemens AG, Erlangen, Germany)

using an 18-channel phased-array body coil. To suppress peristalsis, patients received 20 mg of butyl-scopolamine (Buscopan<sup>®</sup>, Boehringer Ingelheim Pharma, Ingelheim, Germany) intravenously before the examination. MP-MRI included T2-weighted imaging (T2W), diffusion-weighted imaging (DWI), and dynamic contrast-enhanced imaging (DCE). A T2-weighted three-dimensional (3D) turbo spin-echo sequence with variable flip angle (3D SPACE sequence) was used in the axial plane. Axial diffusion-weighted imaging of the prostate, using  $b$ -values of 50, 400, and 2000 s/mm<sup>2</sup> was performed with inline reconstruction from an apparent diffusion-coefficient (ADC) map from which the ADC map was constructed on a voxel-wide basis with a standard mono-exponential. Dynamic contrast-enhanced MRI was obtained using a fat-saturated T1-weighted fast-field echo sequence. After acquisition of unenhanced T1-weighted MR images, dynamic sequences were further acquired after an intravenous administration of 0.2 mL/kg of gadoterate meglumine (Dotarem<sup>®</sup>; Guerbet, Roissy Charles de Gaulle, France). This study followed the START consortium guidelines [9].

### Image analysis

MP-MRI images were analyzed independently by two uro-radiologists with 11 years (R. R.-P., reader 2) and 3 years (M. E., reader 1) of experience in prostate imaging at the start of the study. They knew that patients had undergone radical prostatectomy but were blinded to other patient data. Readers evaluated the MR images obtained with the 3 pulse sequences during the same session. First, they evaluated all prostate lesions of the peripheral zone that showed low signal intensity on T2-weighted images and/or ADC maps and an early enhancement on DCE images. Then, they evaluated all transition zone lesions that showed homogeneous low signal intensity on T2-weighted images, with ill-defined margins, no capsule, and no cyst [10].

All MRI sequences were used to assess TV of the index lesion, whereas the following measurements were performed on T2-weighted images using 3 different techniques

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