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Original Article

Value of T1/T2-weighted magnetic resonance imaging registration to reduce the postbiopsy hemorrhage effect for prostate cancer localization

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ABSTRACT

Background: The aim of this study was to evaluate the value of T1/T2-weighted imaging (T1/T2WI) registration to reduce the postbiopsy hemorrhage effect for prostate cancer localization on prostate magnetic resonance imaging (MRI).

Methods: Twenty-one men with pathology-proven prostate cancer who underwent preoperative MRI in a single institution were selected. The zonal anatomy was divided into 16 sections. T2WI, T1/T2-weighted registered imaging (T1/T2RI), T2WI combined with diffusion-weighted imaging (T2WI + DWI), and T1/T2RI combined with DWI (T1/T2RI + DWI) were scored for the likelihood of cancer by two radiology faculty members and two trainees, and were compared with histology results. Areas under the receiver operating characteristics curve (AUCs) were used to assess diagnostic accuracy.

Results: For the trainees (Reader 3 and Reader 4), the AUC values were significantly higher ($P < 0.05$) for T1/T2RI (0.60 and 0.62, respectively) than for T2WI (0.54 and 0.56, respectively) in tumor detection, whereas no significant difference was observed for faculty members. There was no significant difference in AUC values between T1/T2RI and T2WI + DWI for all readers except for Reader 1. There was no additional diagnostic benefit for adding DWI with T1/T2RI for all readers.

Conclusions: T1/T2WI registration is a feasible technique. For less experienced readers, T1/T2RI is better than T2WI in localization of prostate cancer.

Introduction

The need for the early detection and localization of prostate cancer based on noninvasive magnetic resonance imaging (MRI) has increased with the emergence of local targeted therapies as alternatives to radical prostatectomy or radiation therapy.[1–4] However, despite the expectations that MRI would be useful for primary detection and localization of prostate cancer, it is an unsatisfactory imaging modality because of its limited diagnostic accuracy. Therefore, MRI is currently performed for local staging of prostate cancer confirmed by transrectal ultrasonography-guided biopsy beforehand. However, this routine diagnostic process of prostate cancer has the additional negative effect of reducing the diagnostic performance of prostate MRI owing to postbiopsy hemorrhage. Postbiopsy hemorrhage presents hypointensity on T2-weighted imaging (T2WI) similar to the signal intensity of typical prostate cancer. Although several investigators have reported various methods and imaging techniques for reducing the influence of postbiopsy hemorrhage on T2WI,[5–8] it is still a major problem for localization of the prostate cancer on MRI.

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T1-weighted imaging (T1WI) is often helpful for distinguishing hemorrhage from background tissue, although abnormal lesion such as prostate cancer is indistinguishable due to its poor tissue contrast. Thus, we hypothesized that if we could automatically suppress the signal intensity of hemorrhage on T2WI using its T1 signal intensity, T2 signal intensity of the prostate cancer would be more conspicuous and the diagnostic performance of prostate MRI would be improved. This hypothesis has motivated investigation of the potential usefulness of imaging registration technique by summation of the different signal intensities of hemorrhage from T1WI and T2WI (Fig. 1).

Therefore, we aimed to evaluate the feasibility of T1/T2WI registration technique for reducing the postbiopsy hemorrhage effect on prostate MRI and to assess the diagnostic accuracy of T1/T2-weighted registered imaging (T1/T2RI) for detecting prostate cancer in comparison with T2WI, T2WI combined with diffusion-weighted imaging (T2WI + DWI), and T1/T2RI combined with DWI (T1/T2RI + DWI) in the same patients. Histopathologic sections were used as the reference standard.

Materials and methods

Study populations

Our institutional review board approved this retrospective study and waived the requirement for informed consent. We enrolled 25 men who underwent 1.5-T prostate MRI for the local staging of prostate cancer in a single institution from March to October 2009. The inclusion criteria were as follows: (1) patients in whom prostate cancer had been confirmed by transrectal ultrasonography-guided biopsy within 2 months before undergoing MRI, and in whom radical prostatectomy was performed; (2) patients who had available T1/T2RI generated using an in-house software program, and (3) patients who had available reconstructed whole-mount step-section pathologic tumor maps using an in-house software program after prostatectomy. We excluded patients (1) who had previous prostate cancer treatment or (2) for whom technical problems had interfered with the use of software programs. Among the 25 patients, four were excluded due to the following reasons: technical error of in-house software program ($n = 3$) and previous history of hormone therapy ($n = 1$). As a result, 21 patients (mean age, 68 years ± 5 years; range, 60–75 years) who satisfied the criteria were included for analysis.

MRI protocol

MRI was performed on a 1.5-T scanner (Gyroscan Intera 1.5-T, Philips Medical Systems, Best, The Netherlands) using a pelvic phased-array coil (SENSE-Flex-M coil, Philips Medical Systems). According to the standard prostate MRI protocol at our institution, the images were obtained including transverse T2-weighted [repetition time/echo time (T_R/T_E), 5,900–6,100/120 ms; section thickness, 4 mm; intersection gap, 1 mm; field of view, 150 × 150 mm; matrix, 512 × 512; number of excitations, 3] and T1-weighted fast spin-echo sequences (T_R/T_E, 425–600/8–10 ms; section thickness, 4 mm; intersection gap, 1 mm; field of view, 150 × 150 mm; matrix, 512 × 512; number of excitations, 3). DWI was performed using a single-shot echo-planar imaging technique (b value = 0 and 1,000 s/mm^2) in the axial plane (T_R/T_E, 2,600–4,000/81 ms; section thickness, 5 mm; intersection gap, 1 mm; field of view, 220 × 220 mm; matrix, 256 × 256; number of excitations, 6 or 14).

Imaging registration processing

T1/T2RI was generated based on routine spin-echo sequences of T1WI and T2WI using the Prostate Fusion Tool software program, which was developed in the Visual Computing and Medical Imaging Laboratory (VCMI Lab) at the College of Information and Media, Seoul Women's University, Korea (Fig. 2). Using this program, any signal intensity over a selected threshold value on T1WI was superimposed on T2WI within the specified boundary. In our study, we use the fixed threshold value of T1 signal intensity. The fixed optimal threshold value of T1 signal intensity was selected by a preliminary test using sample data, which was not included in our study.

Image analysis and interpretation

T2WI, T1/T2RI, and DWI were evaluated on a Picture Archiving and Communication Systems workstation (INFINITT Technology, Seoul, Korea). All images were reviewed by four radiologists, including two faculty members (H.J.L. and S.I.H., who had >20 years of experience and 16 years of experience interpreting prostate MRI, respectively) and two trainees (Y.J.B. and J.Y.Y., who are residents having 3 years of radiology experience). Although the readers were aware that the patients had prostate cancer, they were blinded to clinical data and pathologic results. They were provided with a description of the principle of image registration and some example before imaging interpretation.

T2WI, T1/T2RI, T2WI + DWI, and then T1/T2RI + DWI were independently reviewed. The imaging quality of T1/T2RI was analyzed according to three categories as follows: (1) good (no artifact); (2) adequate (the presence of minor image-degrading artifacts but feasible for imaging interpretation with moderate confidence); and (3) poor (the presence of major image-degrading artifacts enough to disturb imaging interpretation).

The zonal anatomy of the prostate was divided into 16 regions, modified from the result of the 2011 European Consensus Meeting.[9] First, the prostate was divided into the base, middle, and apex regions. According to the description by Haider et al,[10] the base was defined as the region extending from the most superior margin to the widest transverse diameter of the prostate. The middle was defined as the region between the widest transverse diameter of the prostate and the orifices of the ejaculatory ducts at the

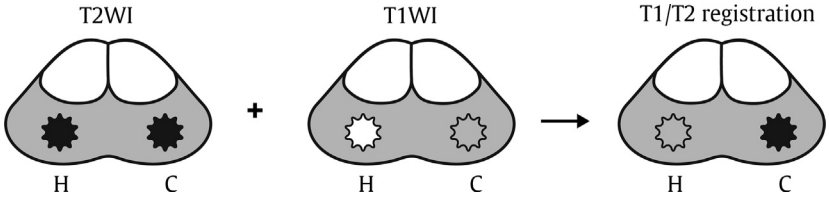

Fig. 1. The basic concept of T1/T2-weighted imaging (T1/T2WI) registration. The signal intensity of hemorrhage (H) is same as that of prostate cancer (C) on T2WI; however, it is different on T1WI. To reduce the hemorrhage effect on T2WI, any T1 signal intensity above a selected threshold value is superimposed on T2WI using the imaging registration technique. After undergoing this process, T2 signal intensity of the prostate cancer would be more conspicuous, whereas that of the hemorrhage would be suppressed.