의학석사 학위논문

Value of T1/T2-weighted MR imaging registration to reduce effect of post biopsy hemorrhage in localization of prostate cancer

전립선암의 국소화에 있어서 생검 후 출혈의 영향을 줄이기 위한 T1/T2 강조 자기공명영상 정합의 가치

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ABSTRACT

Introduction: The objective of our study was to evaluate feasibility of T1/T2-weighted MR imaging registration (T1/T2 registration) for reducing effect of post-biopsy hemorrhage in localization of prostate cancer and compare the diagnostic accuracy between T2-weighted imaging and T1/T2 registration imaging in the same patients with histopathologic sections as the reference standard.

Methods: This institutional review board-approved retrospective study was performed in a total 25 consecutive men who had biopsy-proven prostate cancer and underwent 1.5T phase array coil MR examination in a single institution from March 2009 to October 2009. Among them, we selected 21 patients (mean age, 68 years; range, 60-75 years) who were available to use histopathologic sections as the reference standard. The zonal anatomy was divided into 16 sections. T2-weighted imaging and T1/T2 registration imaging were scored for the likelihood of cancer by four radiologists (2 faculty and 2 trainees), and finally compared with histology results. Areas under the receiver operating characteristics curve (AUCs) were used to assess diagnostic accuracy.

Results: For trainees (reader 3 and 4), the AUC values were significantly higher ($p<.05$) for T1/T2 registration imaging (0.60 and 0.62, respectively) than for T2-weighted imaging (0.54 and 0.56, respectively) in tumor detection, whereas there were no significant differences of AUCs between two imaging for faculty. Specificity was also significantly higher ($p=0.02$ and <0.001) with

T1/T2 registration imaging than T2-weighted imaging for trainees.

Conclusions: T1/T2 registration imaging can be used to reduce post-biopsy hemorrhage effect in localization of the prostate cancer, especially for radiology trainees.

Keywords: Image registration, Prostate cancer, Biopsy, Hemorrhage, Magnetic Resonance Imaging

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LIST OF ABBREVIATIONS

T1/T2 registration = T1/T2-weighted MR imaging registration

ROC = receiver operating characteristic

AUC = area under the receiver operation characteristic curve

INTRODUCTION

The need for the early detection and localization of prostate cancer based on the non-invasive MR imaging has been increased with the emergence of local targeted therapies as alternatives to radical prostatectomy or radiation therapy(1-4). However, despite these expectations of MR imaging, it is a fairly unsatisfied imaging modality for primary detection and localization of the prostate cancer due to limited diagnostic accuracy. Therefore, MR imaging is currently performed for local staging of prostate cancer which was prior confirmed by transrectal ultrasonography-guided prostate biopsy. This routine diagnostic process of the prostate cancer causes another vicious circle to reduce the diagnostic performance of prostate MR imaging due to post-biopsy hemorrhage, which presenting low signal intensity on T2-weighted imaging same as typical prostate cancer. Several investigators have reported various methods and imaging techniques to reduce the influence of post-biopsy hemorrhage on T2-weighted imaging(5-8). However, it is still remained as a major tough problem in evaluating prostate cancer on MR imaging.

If we could subtract hemorrhage signal intensity on T2-weighted imaging using its T1- signal intensity because hemorrhage generally shows high signal intensity on T1-weighted imaging unlike prostate cancer, T2-signal intensity of the prostate cancer itself would be more conspicuous and the diagnostic performance of prostate MR imaging would be also improved. This hypothesis has motivated investigation of the potential usefulness of imaging registration technique by summation mutual different signal intensity of hemorrhage from T1- and T2-weighted imaging.

Therefore, we aimed to evaluate feasibility of T1/T2-weighted MR imaging registration (T1/T2 registration) technique for reducing post-biopsy hemorrhage effect in localization of prostate cancer and compare the diagnostic accuracy between standard T2-weighted imaging and T1/T2 registration imaging in the same patients with histopathologic sections as the reference standard.

MATERIALS AND METHODS

1. Study Populations

Our institutional review board approved this retrospective study and waived the requirement for informed consent. Twenty-five men who underwent 1.5T prostate MR imaging for staging of prostate cancer in a single institution from March to October 2009 were enrolled. The inclusion criteria from our study were as follows: (a) patients who had confirmed as a prostate cancer by transrectal ultrasonography-guided prostate biopsy within 2 months before the MR imaging, (b) patients who had available T1/T2 registration imaging generated by using software program, and (c) patients who had available reconstructed whole-mount step-section pathologic tumor maps by using software program after radical prostatectomy. We excluded patients (a) who had previous prostate cancer treatment, including surgery, hormone therapy, or radiation, or (b) whose MR imaging was non-diagnostic due to severe artifacts including motions or susceptibility artifacts, or (c) who had technical problem to use software programs. Among 25 patients, four patients were excluded because of non-available reconstructed whole-mount histopathologic tumor maps due to technical problem. As a result, a total of 21 patients (mean age 68± 5 years; range 60-75) who matched our needs, were finally included for analysis.

2. MR imaging protocol

MR imaging was performed on a 1.5-T scanner (Gyroscan Intera 1.5T,

Philips Medical Systems, Best, The Netherlands) using a pelvic phased-array coil (SENSE-flex-M coil, Philips Medical Systems). As the standard clinical prostate MR examination at our institution, the images obtained including transverse T2-weighted (repetition time /echo time, 3000-6000/100-120msec; section thickness, 4 mm; intersection gap, 1 mm; field of view, 150 × 150mm; matrix, 512 x 512) and transverse T1-weighted fast spin-echo sequences (repetition time /echo time, 425-500/8-10msec; section thickness, 4 mm; intersection gap, 1 mm; field of view, 150 × 150mm; matrix, 512 x 512).

3. Imaging Registration Processing

T1/T2 registration imaging was generated based on routine T1-weighted and T2-weighted spin-echo sequences by using 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. By using this program, any T1 signal intensity above selected threshold value was superimposed on T2-weighted imaging within appointed boundary. Threshold value of T1 signal intensity can be adjusted before the imaging registration by an operator. In our study, we used fixed optimal threshold value selected by preliminary test with sample data of eight patients which was not included in our study. Final registration imaging was converted to jpg images.

4. Image analysis and Interpretation

T2-weighted imaging was evaluated on a workstation (Infinitt Technology,

Seoul, Korea). T1/T2 registration imaging was displayed using jpg image files. All images were reviewed by four radiologists (2 faculty; H.J.L. with more than 20 years of experience and S.I.H. with 16 years of experience interpreting prostate MR imaging, 2 trainees; Y.J.B and J.Y.Y with 3 years of experience interpreting prostate MR imaging). The readers were aware that the patients had prostate cancer. However, they were blinded to clinical data and pathologic results. They were given a description of the principle of image registration and a few example data. T2-weighted imaging was reviewed first and then T1/T2 registration imaging was reviewed independently. To prevent a memory effect on the imaging interpretation, an interval of at least 4 weeks was interposed between T2-weighted imaging and T1/T2 registration imaging for reading. Moreover, T1/T2 registration imaging was reviewed in a different order from T2-weighted images.

The zonal anatomy of the prostate was divided into 16 regions, modified from the result of 2011 European Consensus Meeting(9). First of all, the prostate was divided into base, mid, and apex. As follow the description by Haider et al. (10), the base was defined as the region extending from the most superior margin of the prostate to the widest transverse diameter of the prostate. The mid gland was defined as the region between the widest transverse diameter and the orifices of the ejaculatory ducts at the verumontanum. The apex was defined as the region inferior to the mid gland. The central gland comprising the transition zone and central zone was additionally divided into left and right halves from base to apex, yielding 6 regions. The peripheral zone of the prostate was subdivided into four quarters

(left lateral, left medial, right medial and right lateral regions) at mid and base levels, whereas into left and right halves at the apex. Thus, mid and base of the prostate were composed of 6 regions and apex of 4 regions. The reviewers assigned a score to each local region for the likelihood of cancer using the following 5-point index scale: 0, definitely no cancer; 1, probably no cancer; 2, possible cancer; 3, probable cancer; and 4, definite cancer.

5. Histopathologic Analysis and Image correlation

After prostatectomy, the prostate specimens were embedded in formalin. After removal of the apex and bladder neck resection margins, the prostate was sliced form apex to base at internals of 3-4mm. These slices were sectioned into two halves (left and right) or four quarters (left anterior, left posterior, right anterior and right posterior) to fit on a standard slide. A pathologist outlined the region of cancer before being digitally imaged. All sectioned slides were digitized and reconstructed into whole-mount sections automatically using Pathology Stitching & Correction Tool software program which was developed by the VCMI Lab at the College of Information and Media, Seoul Women's University, Korea. If automatic stitching image showed misalignment, additional manual manipulation was applied using rotation or x-, y-position correction. The region was considered positive for cancer if it contained tumor with a cross-sectional area that was greater than 0.5 cm^2 on the fixed specimen with a Gleason score of 6 or higher.

For the purposes of radiologic-pathologic correlation, a radiologist reviewed the pathologic specimens to in conjunction with the MR imaging to spatially

match tumors in each region. MR imaging and pathologic step-section slices were paired on the basis of the anatomic landmarks such as the prostatic urethra, prostate zones, ejaculatory ducts, and verumontanum and approximate distance from the base or apex.

6. Statistical analyses

All the statistical analyses were performed by using commercially available software (MedCalc, version 12.5.0; MedCalc, Mariakerke, Belgium). *P* values less than .05 were considered statistically significant difference. The analysis was performed with the assumption that the multiple sectional zones of the prostate in the same patient were approximately independent of each other. Receiver operating characteristic (ROC) curves were estimated separately for each region of the prostate using maximum likelihood. The area under the receiver operating characteristics curve (AUC) was compared between T2-weighted imaging and T1/T2 registration imaging for each reader. The diagnostic sensitivity, specificity, and positive and negative predictive values were estimated for differences between methods by choosing a threshold score of 2 or greater to indicate cancer, together with 95% confidence intervals, separately for each reader. Interobserver agreement was evaluated by using the weighted k statistic, which was interpreted based on the table provided by Landis and Koch(11) as follows: poor (<0.20), fair (0.21-0.40), moderate (0.41-0.60), good (0.61-0.80), and excellent agreement (0.81-1.00).

RESULTS

Patients' characteristics are summarized in Table 1.

Table 1 Patient Characteristics

Characteristic	Value
Mean age (years)	68 (60-75)
Mean preoperative PSA level (ng/ml)	7.645 (4.7-13.3)
Maximum Gleason score	
6	1
7	18
8	2
Pathologic stage	
T2a	0
T2b	0
T2c	13
T3a	7
T3b	1
Interval between biopsy and MRI(days)	
≤14	N=9
>14	N=12
Mean tumor volume	14(1-80%)
Number of tumor nodules(≥5mm)	
In peripheral zone	67
In central zone	53

Of the total 336 regions, 120 regions contained cancers which were greater than 0.5 cm^2 with a Gleason score of 6 or more. Among them, 67 cancers

were located in peripheral zone. The mean interval from MR imaging to surgery was 19 days (range 7 to 38). The quality of T1/T2 registration imaging was acceptable for interpretation without severe misregistration artifact. For the detection of prostate cancer, reader 1 and reader 2 as the faculty achieved the AUC values of 0.60 and 0.62, respectively for T2-weighted imaging and the same AUC values of 0.60 and 0.62, respectively for T1/T2 registration imaging. There was no significant difference between the two imaging sequences. However, the AUC values were significantly higher for T1/T2 registration imaging (0.60 and 0.62, respectively) than for T2-weighted imaging (0.54 and 0.56, respectively) in reader 3 and 4 as trainees (p=0.03 and 0.04, respectively) (Figure 1).

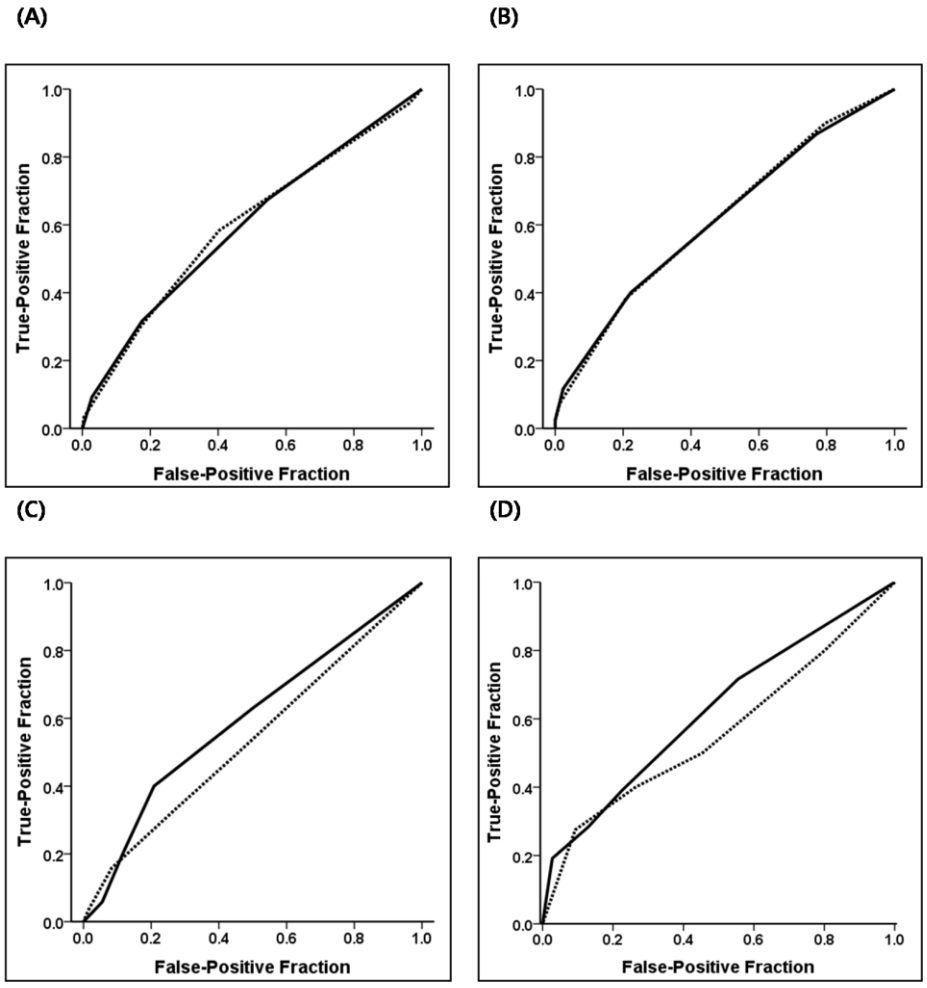

Figure 1 ROC curves for detection of prostate cancer on T2-weighted imaging (dashed line) and T1/T2 registration imaging (solid line)

(A) For reader 1, Test performance was poor (p=0.93) with T2-weighted imaging (AUC=0.60) and registration imaging (AUC=0.60) AUC

(B) For reader 2, Test performance was poor (p=0.97) with T2-weighted imaging (AUC=0.62) and registration imaging (AUC=0.62)

(C) For reader 3, AUC was significantly higher (p=0.03) for and registration imaging (AUC=0.60) than for T2-weighted imaging (AUC=0.54)

(D) For reader 4, AUC was significantly higher (p=0.04) for registration imaging (AUC=0.62) than for T2-weighted imaging (AUC=0.56)

On T2-weighted imaging, the AUC value of the faculty was higher than that of the trainees, even though significant statistical difference was only shown between reader 2 and 3(p=0.03). On T1/T2 registration imaging, there was no significant difference for the AUC value among all readers.

Table 2 summarizes sensitivities, specificities, and positive and negative predictive values, using a threshold score of 2 or greater to indicate cancer. Specificity was significantly higher for T1/T2 registration imaging than for T2-weighted imaging for trainees (p=0.02 and <0.001 for reader 3 and 4, respectively). Especially for reader 4, specificity was significantly higher for T1/T2 registration imaging than for T2-weighted imaging without overlap of the confidence intervals (77.31%, [71.14- 82.72]; 95% CI vs. 54.63%, [47.73-61.40]; 95% CI, p<.001). Interobserver agreement for the detection of prostate cancer was fair with 0.23-0.40 kappa value on both T2-wighted imaging and T1/T2 registration imaging among all readers. Interobserver agreements between trainees or the faculty were also fair.

Table 2 Qualitative Assessment of Diagnostic performance of T2-weighted imaging vs. T1/T2 registration imaging for prostate cancer

	R1			R2			R3			R4		
	T2WI	Subtraction	*p*	T2WI	Subtraction	*p*	T2WI	Subtraction	*p*	T2WI	Subtraction	*p*
Sensitivity	58.33%	67.50%	.10	38.33%	40.00%	.84	33.33%	41.67%	.09	50.00%	39.17%	.03
	[48.98-67.26]	[58.35-75.77]		[29.61-47.65]	[31.17-49.34]		[24.99-42.52]	[32.74-51.02]		[40.74- 59.26]	[30.39- 48.50]	
Specificity	59.72%	45.37%	.00	79.17%	77.78%	.77	72.69%	79.17%	.02	54.63%	77.31%	<.001
	[52.85-66.32]	[38.60-52.27]		[73.13-84.38]	[71.64-83.14]		[66.23-78.51]	[73.13-84.38]		[47.73- 61.40]	[71.14- 82.72]	
PPV	44.59%	40.70%	.69	50.55%	50.00%	.46	40.4%	52.63%	.06	37.97%	48.96%	.72
	[36.66-52.72]	[33.81-47.88]		[39.86-61.20]	[39.62-60.38]		[30.66-50.74]	[42.12-62.97]		[30.38- 46.03]	[38.61- 59.37]	
NPV	72.07%	71.53%	.99	69.80%	70.00%	.32	66.24%	70.95%	.09	66.29%	69.58%	.33
	[64.88-78.50]	[63.20-78.91]		[63.63-75.48]	[63.77-75.73]		[59.84-72.24]	[64.78-76.60]		[58.84- 73.19]	[63.34- 75.34]	

*Note- Regions scored as 2 or greater were considered positive. The 95% CIs are in square brackets. R: reader, PPV=positive predictive value, NPV= negative predictive value

DISCUSSION

The present study evaluated the feasibility of T1/T2 registration imaging to reduce post-biopsy hemorrhage effect on T2-weighted imaging and showed the significant higher AUC value and specificity for detection and localization of prostate cancer with T1/T2 registration imaging than T2-wieghted imaging for radiology trainees.

Imaging registration technique is widely used in radiologic fields such as breast dynamic contrast-enhanced MRI and MR angiography to improve the lesion detection rate. It is usually applied in purpose of comparison of one subject to surrounding another subject or monitoring of interval changes in an individual during a serial follow-up. It is routinely used in rigid organs such as brain, while less commonly in movable body organs(12-14). Imaging registration in the prostate which is a relatively non-movable and rigid body organ has been described in a few publications, often for measurement of the prostate volume, guidance of image-based localized therapy or fusion between MR imaging and histologic specimen(15-18). To the best of our knowledge, imaging registration technique has not yet been used in the analysis of reducing post-biopsy hemorrhage effect in the prostate.

On MR imaging, T2-low signal intensity of prostate cancer is difficult to distinguish from that of prostatitis, benign prostatic hypertrophy or post-biopsy hemorrhage(19). Among them, the influence of post-biopsy hemorrhage is the most powerful factor to interfere with localizing the cancer on T2-weighted imaging. To eliminate the influence of post-biopsy

hemorrhage on MR imaging, some authors proposed adjustment of time interval between biopsy and MR imaging(6-8, 20). However, it was not quite effective due to individual variation of period in disappearing post-biopsy hemorrhage. Barrett et al. recently rather attempted to use post-biopsy hemorrhage for cancer identification with the hemorrhage exclusion sign on T1-weighted imaging, because post-biopsy hemorrhage is inevitable in most cases(5). In our study, we used imaging registration technique to reduce post-biopsy hemorrhage effect on T2-weighted imaging, based on the difference of T1-signal intensity between cancer and hemorrhage.

Our study showed that this technique was feasible. In cases with little post-biopsy hemorrhage, T1/T2 registration imaging was not quite different from T2-weighted imaging. However, the effect of T1/T2 registration imaging was dramatic in cases with obvious post-biopsy hemorrhage. In those cases, T2-low signal intensity of hemorrhage was completely covered by its T1-high signal intensity using image registration technique, so it showed almost same signal intensity with surrounding normal prostate tissue on T1/T2 registration imaging(Figure 2).

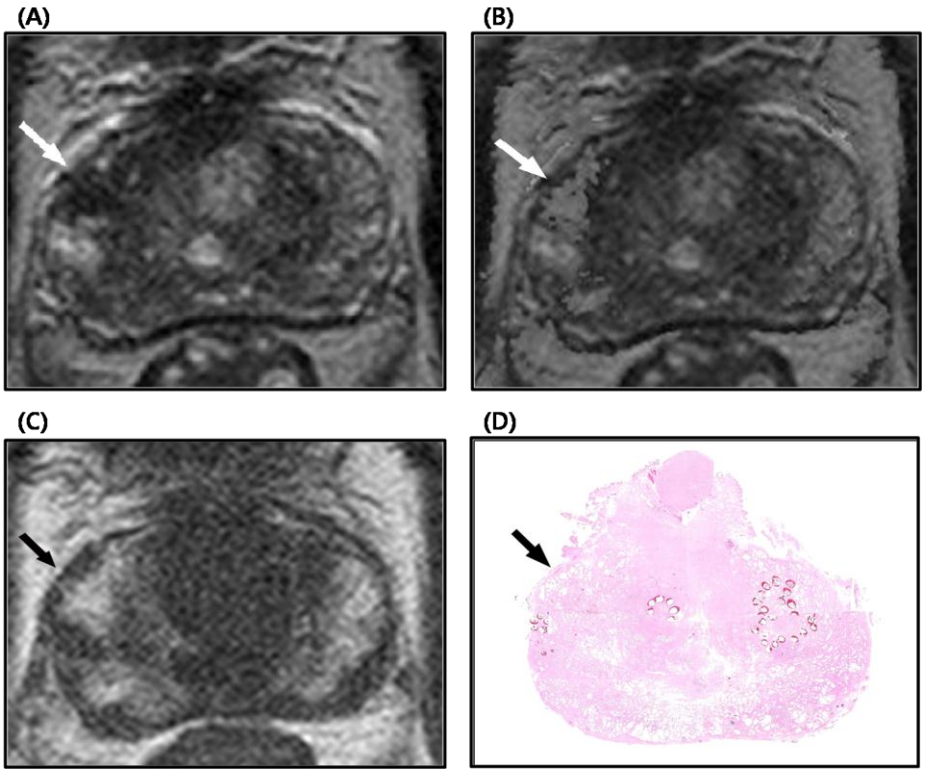

Figure 2 High specificity on T1/T2 registration MR imaging in 74-year-old man with prostate cancer

(A) T2-weighted image shows focal area of low signal intensity in right lateral peripheral zone at the base of the prostate (arrow). This region was scored as more than 2 (possible cancer) by three readers.

(B) T1/T2 registration image shows no low signal intensity in the corresponding area (arrow). This region was scored as 0 or 1 by all readers.

(C) T1-weigthed image show focal high signal intensity in that region, suggestive of hemorrhage.

(D) Photomicrograph of pathologic specimen shows no tumor in that region.

In some cases with prostate cancer which was partially overlapped with post-biopsy hemorrhage, a trend was seen that margin of the cancer was more clearly delineated on T1/T2 registration imaging than T2-weighted imaging (Figure 3).

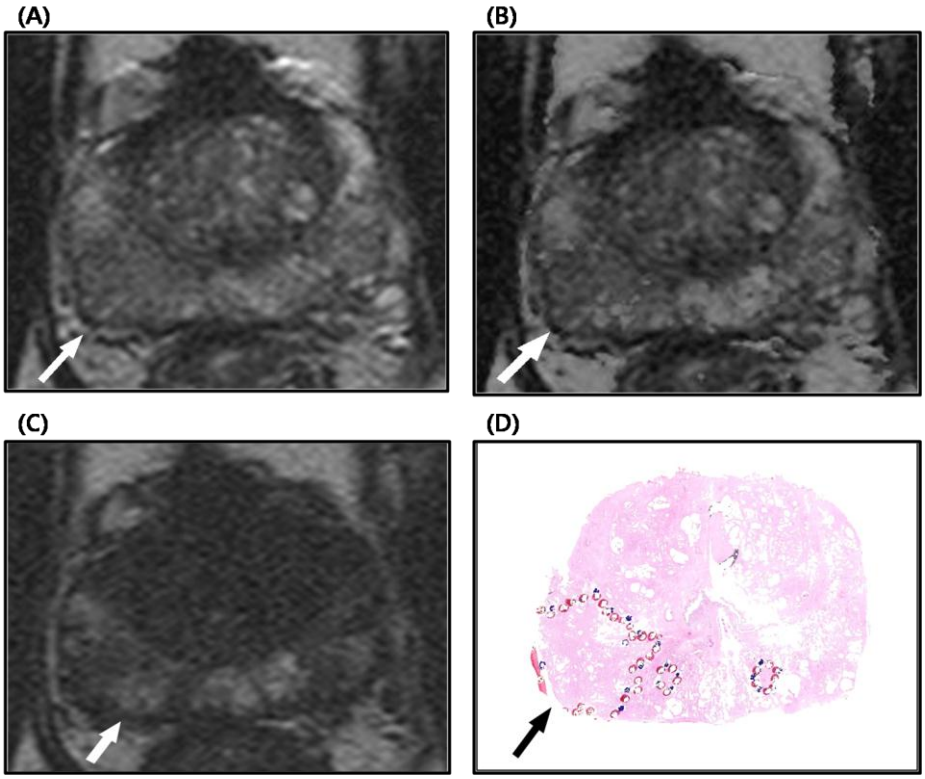

Figure 3 Good conspicuity on T1/T2 registration MR imaging in 67-year-old man with prostate cancer

(A) T2-weighted image shows suspicious focal area of low signal intensity in right posterior peripheral zone at the apex of the prostate (arrow). Interobserver agreement for this region was poor.

(B) On T1/T2 registration image, the corresponding lesion shows more

conspicuous low signal intensity due to relatively clear margin of the tumor (arrow).

(C) T1-weigthed image show focal high signal intensity in that region, suggestive of partial hemorrhage.

(D) Photomicrograph of pathologic specimen shows Gleason score of 7 tumor (outlined area with arrow) in that region.

Furthermore, the quality of our T1/T2 registration imaging was acceptable. Interface artifact between hemorrhage and surrounding tissue due to misregistration was minor and negligible. The quality of registration imaging seems to be decided by that of routine T1- and T2- weighted imaging.

The present study showed the significant higher AUC value and specificity for detection and localization of prostate cancer with T1/T2 registration imaging than T2-wieghted imaging for radiology trainees. However, faculty might be disappointed to get diagnostic gain on T1/T2 registration imaging. This result is not clearly understandable because post-biopsy hemorrhage effect was truly eliminated on T1/T2 registration imaging. One possible explanation is due to poor intraobserver reliability to detect prostate cancer on MR imaging regardless of any sequences. In our study, only one cancer region showed true high signal intensity on T1/T2 registration imaging among the all false negative regions on T1/T2 registration imaging (Figure 4).

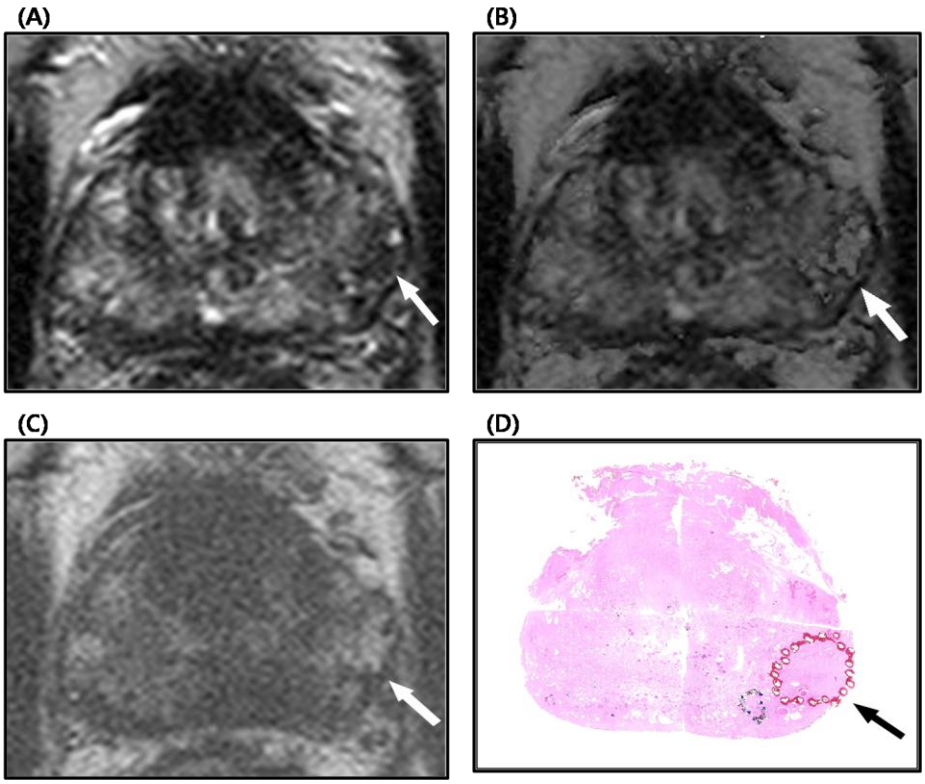

Figure 4 False negative case of T1/T2 registration imaging in 63-year-old man with prostate cancer

(A) T2-weighted image shows focal area of low signal intensity in left lateral peripheral zone at the base of the prostate(arrow). This region was scored as more than 2 (possible cancer) by three readers.

(B) T1/T2 registration image shows no definite low signal intensity in the corresponding area (arrow), except for subtle peripheral low signal intensity line. This region was scored as less than 1(probably no cancer) by three readers.

(C) However, T1-weigthed image show focal high signal intensity in that region, suggestive of hemorrhage.

(D) Photomicrograph of pathologic specimen shows Gleason score of 9 tumor (outlined area with arrow) in that region.

It means the other false negative regions on T1/T2 registration were judged as absence of the cancer by readers, even though obvious low signal intensities of the cancer were noted due to intraobserver variation. Another possible reason is the size and location of post-biopsy hemorrhage. Even though we did not stratify the lesions according to tumor size or location due to its small data size, if post-biopsy hemorrhage was located in central portion of the cancer or completely covered whole tumor, T1/T2 registration imaging would not be quite effective. Further subgroup analyses according to these factors in large population may be help to achieve exact diagnostic performance with T1/T2 registration imaging in all radiologists.

There are several limitations on our study. First, this was a small size retrospective study using 1.5 T MR imaging. Second, T1/T2 image registration technique is not available on workstation until now because it is still under development. Third, the analysis in our study was performed with the assumption that the multiple sectional regions of the prostate in the same patient were independent each other. Fourth, misregistration artifacts were identified in some cases, even though they were all minor.

In summary, the feasibility of T1/T2-weighted imaging registration technique was shown for reducing the effect of post-biopsy hemorrhage on T2-weighted imaging in our study. While a conclusive proof is lacking due to small size data that the diagnostic performance of T1/T2 registration imaging

is better than that of T2-weighted imaging for prostate cancer, it remained noticeable that T1/T2 registration imaging made low signal intensity of the prostate cancer itself much more conspicuous than T2-weighted imaging and at least it increased diagnostic performance for prostate cancer in radiology trainees. However, further large clinical studies are necessary to prove the value of T1/T2 registration imaging to increase radiologists' productivity and consistency for interpretation of prostate cancer. If this procedure is successful, then it can be a useful problem–solving technique and help the physician to appropriately apply localized treatments.

In conclusion, T1/T2 registration imaging can be used to reduce post-biopsy hemorrhage effect in localization of prostate cancer, especially for radiology trainees.

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국문 초록

서론: 본 연구는 MRI 에서 전립선암을 국소화하는 데 있어서 가장 큰 방해 요소인 생검 후 출혈의 영향을 줄이기 위해 T1/T2 강조 자기공명 영상 정합 기법을 이용하였다. 본 연구의 목적은 이러한 정합기법이 임상적으로 실행 가능한지를 평가하고 전립선암을 진단함에 있어서 기존의 T2 강조 영상과 비교하여 T1/T2 강조 자기공명 영상 정합 영상의 진단능에 차이가 있는지를 병리소견을 바탕으로 알아보고자 하였다.

방법: 본 후향적 연구는 IRB 의 승인 하에 시행되었으며, 2009 년 3 월부터 2009 년 10 월까지 한 개의 의료기관에서 생검으로 확인된 전립선암 환자들 중 수술 전 위상배열 코일을 이용한 1.5T MRI 를 시행 받은 25 명의 환자를 대상으로 하였다. 그 중 병리 조직 분석이 가능한 21 명의 환자들(평균 68 세; 60-75 세)만이 최종적으로 본 연구에 포함되었다. 전립선은 총 16 개 구역으로 분류하였으며 각각의 구역에 대하여 4 명의 영상의학과 의사(2 명의 전문의 교수, 2 명의 수련의)가 T2 강조 영상과 T1/T2 강조 자기공명정합 영상에서의 전립선암 여부를 평가하여 점수화 하였다. 최종적인 암의 유무는 병리조직과의 비교를 통해 확인하였다. 또한 각 진단 영상에 따른 ROC 곡선을 그리고 AUC(ROC 곡선하면적) 값을 비교하였다.

결과: 전문의 교수들(판독의 1 과 2)은 전립선암 진단에 있어서 T2 강조 영상과 T1/T2 강조 자기공명정합 영상의 진단능이 통계적으로 유의한 차이를 보이지 않았으나 수련의들(판독의 3 과 4)은 T1/T2 강조 자기공명정합 영상의 진단능이 통계적으로 유의하게 T2 강조 영상보다 높았다(p=0.03 과 0.04). 판독의 3 과 4 는 T2 강조영상에서의 AUC 값이 각각 0.54 와 0.56 으로 측정된 반면, T1/T2 강조 자기공명정합 영상에서의 AUC 값은 각각 0.60 과 0.62 으로 증가하였다. 진단특이도 역시 수련의들은 T1/T2 강조 자기공명정합 영상이 T2 강조영상보다 유의하게 높았다(p=0.02 와 <0.001).

결론: 결론적으로 T1/T2 강조 자기공명 정합기법은 전립선암을 국소화하는데 있어서 생검 후 출혈의 영향을 줄이는 데 이용될 수 있으며, 특히 영상의학과 수련의들에게 그 이용가치가 더 높았다.

주요어 : 영상 정합, 전립선암, 조직검사, 출혈, 자기공명영상

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