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Direct MRI-guided biopsy of the prostate: use of post-biopsy needle track imaging to confirm targeting

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Abstract

Purpose—To report the observation that in-plane post-biopsy T2-weighted MRI often demonstrates the needle track as a transient visible linear tissue distortion during direct MRI-guided biopsy.

Materials and methods—We retrospectively identified 11 prostatic lesions in 9 men that underwent direct MRI-guided biopsy and in which post-biopsy images were obtained in the plane of the biopsy needle.

Results—In 9 of 11 targets, a post-biopsy needle track was visible as a linear tissue distortion on in-plane T2-weighted images obtained at a mean interval of 6 min (range 3–15). In these nine cases, the needle track traversed the intended target, and the biopsy was positive for malignancy in six. Biopsy was positive in one of two cases where the needle track was not visible. In five targets, one or more delayed series were obtained after a mean interval of 21 min (range 8–33), showing the track was no longer visible ($n = 3$) or was of progressively decreased conspicuity ($n = 2$).

Conclusion—Accurate targeting during direct MRI-guided biopsy of the prostate can be confirmed by obtaining post-biopsy in-plane images, since the needle track is usually visible as a transient linear tissue distortion.

Keywords

Prostate; Multiparametric MRI; MRI-guided biopsy

Most of the 1.5 million prostate biopsies performed every year in the United States [1] are done with ultrasound guidance, using a transrectal transducer to find the prostate (not the cancer) and direct needle sampling from multiple (6–12 or more) standard locations in the gland. The development of robust multiparametric MRI for tumor visualization has led to

the concept of targeted biopsy, in which biopsy samples are obtained only from the dominant disease site or sites seen at MRI [2, 3]. The hope is that MRI-guided biopsy, whether performed under direct guidance in the bore of the scanner or by fusion of MRI images to real-time transrectal ultrasound [4–6], will reduce the high false negative and tumor under-grading rates associated with the standard non-targeted approach [2, 3]. One question that arises during direct MRI-guided biopsy is how can we be assured that the sample is from the intended location? Imaging of the deployed needle within the patient is an option [5], but necessarily requires leaving the needle in place for many minutes while the appropriate sequences are obtained. Such an approach raises concerns regarding patient comfort and potentially increased risk of bleeding or infection associated with prolonged needle “dwell time”. These risks have not been specifically documented in the case of MRI-guided prostate biopsy, but such concerns appear legitimate given that short dwell times are generally considered advantageous during needle biopsies [7]. The purpose of this study is to describe a new method of confirming sample location by depiction of the post-biopsy needle track as a linear tissue distortion on T2-weighted images obtained in the plane of the biopsy core.

Materials and methods

Subjects

This was a retrospective single institutional study approved by our Institutional Review Board with waiver of the requirement for informed consent. The study was compliant with the Health Insurance Portability and Accountability Act. We performed a search of our radiology information system to identify all patients ($n = 13$) who underwent direct MRI-guided prostate biopsy since this technique was introduced at our institution. The accrual period was October 2013 to December 2014. We excluded patients in whom post-biopsy images were not obtained in the plane of the biopsy core ($n = 4$). This resulted in a final study population of 9 men with a mean age of 68 years (range 60–76).

Identification of MRI targets

All patients underwent biopsy after an initial diagnostic endorectal multiparametric MRI demonstrated one or more appropriate targets. The detailed scan protocol is shown in Table 1. Two attending radiologists (FVC and BRF) reviewed all images on a picture archiving and communication system workstation (Impax; Agfa, Mortsel, Belgium) and identified potential biopsy targets by consensus. Using an amalgam of published experience [4–6], biopsy targets were defined as foci of low T2 signal intensity with an ellipsoid or crescentic subcapsular morphology in the peripheral zone or infiltrative “erased charcoal” non-encapsulated appearance in the central gland accompanied by focal reduction in apparent diffusion coefficient or accompanied by focal early intense enhancement or rapid washout at perfusion imaging.

Direct MRI-guided biopsy technique

All biopsies were performed by a single attending radiologist (FVC) on a 3T whole-body MRI scanner (Ingenia; Philips Healthcare, Netherlands) with the patient prone and utilizing a commercially available prostate biopsy system (DynaTRIM, Invivo, Gainesville, FL) in

conjunction with a related software package for device tracking and target localization (DynaCAD, Invivo, Gainesville, FL). A qualified radiology nurse provided conscious sedation during the procedure, using intravenous fentanyl and midazolam, with dosage titrated to effect. The biopsy system incorporates a surface coil within the tabletop with an additional surface coil placed posteriorly on the patient. The needle sleeve of the biopsy system, a fingerlike rigid hollow device that functions both as a guide and as a fiducial marker, was lubricated with topical anesthetic ointment and inserted in the rectum and attached to a clamp stand that attaches to the tabletop and establishes rigid co-registration between the needle sleeve, the patient, and the scanner. The patient was advanced into the scanner and T2 axial images obtained, using the same parameters as the initial diagnostic scan (Table 1). The location of the needle sleeve was marked and calibrated to the system and the center of the target lesion(s) was identified. These positional data allow the software to calculate three-dimensional manual adjustments for marked cogs on the device that direct the needle to the target. If necessary, targeting and reconfirmation were repeated until needle track and target were correctly aligned. The patient was then removed from the scanner and two biopsy cores were obtained from each target using an automatic titanium 18G MRI-compatible biopsy gun (InVivo, Gainesville, FL). Post-biopsy T2 images were obtained in the plane of the biopsy deployment. Two attending radiologists (FVC and BRF) reviewed post-biopsy images and noted whether or not a post-biopsy needle track was visible and whether it traversed the intended target, by consensus. A post-biopsy needle track was defined as a linear tissue distortion in the expected path of the biopsy needle that was not present on the corresponding pre-biopsy images. Both readers also noted if delayed in-plane images were obtained, the timing of such images, and the presence or absence of a post-biopsy needle track on these later images. Time intervals from biopsy to scanning were calculated using the mid-point of each sequence, based on the time stamps in PACS.

Results

The clinical and imaging characteristics of the nine patients in the study group are shown in Table 2. The study population consisted of five men with clinically suspected prostate cancer and four men with biopsy confirmed untreated prostate cancer. A total of 22 MRI-guided biopsy cores were obtained from 11 target lesions (two patients each had two targets). In nine of 11 (82%) targets, a post-biopsy needle track was visible as a linear tissue distortion on T2-weighted images obtained in the plane of the biopsy core (Figs. 1, 2) In these nine cases, the needle track traversed the intended target, and the biopsy was positive for malignancy in six. Biopsy was positive in one of two cases where the needle track was not visible. In five targets in five separate patients, one or more sets of delayed images were obtained after a mean interval of 21 min (range 8–33). In three of these cases, the needle track was no longer visible and in the other two cases, the needle track was of progressively decreased conspicuity.

Discussion

Our study suggests that the adequacy of needle targeting during direct MRI-guided biopsy of the prostate can be confirmed by obtaining in-plane post-biopsy T2-weighted images, since in most cases the needle track can be visualized as a linear distortion of the tissue along the

needle path. We believe direct visualization of the needle path at direct MRI-guided biopsy of the prostate is a previously undescribed phenomenon that can be helpful in confirming correct positioning. Documentation of appropriate targeting is good practice, analogous to the American College of Radiology recommendations for MRI-guided breast biopsy [8], and increases confidence that negative pathology represent a true rather than false negative result. The alternative method of imaging the deployed needle [5] remains an option, although we have speculative concerns that the longer needle “dwell time” required for such an approach may increase patient discomfort or be associated with a greater risk of bleeding or infection. The biological basis for the MRI appearance of the post-biopsy needle track is unknown, although our findings at delayed imaging indicate it is a transient phenomenon and so may represent relatively short-lived bleeding, edema, or tiny air bubbles along the needle track. However, knowledge of the underlying biological changes is not required for the finding to be clinically useful.

In a prior combined clinical and phantom study addressing the accuracy of needle placement during direct MRI-guided biopsy [9], significant deviation of the needle from the intended target point was observed due to both needle deflection and needle guide misalignment. The largest source of error was deflection of needles with an asymmetric bevel, with distance from the true target ranging from 3.2 to 8.7 mm.

Our study has several significant limitations. This was a small retrospective study from a single institution based on procedures performed by a single operator. Our study is accordingly primarily descriptive and should be regarded as a preliminary technical note. Confirmation that a target appears to have been traversed is not the absolute reference standard for validating the tissue diagnosis. Benign pathology could still represent a false negative result, and ultimately the distinction of true from false negatives would require radical prostatectomy with step section analysis. That is, it is almost unknowable as to whether a benign biopsy result represents a true negative or a false negative, unless that patient subsequently receives a diagnosis of prostate cancer based on a positive result of another biopsy and then proceeds to radical prostatectomy.

In conclusion, accurate targeting during direct MRI-guided prostate biopsy can be confirmed by obtaining post-biopsy in-plane images, since the needle track is usually visible as a transient linear tissue distortion.

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References

1. Siegel R, Ward E, Brawley O, Jemal A. The impact of eliminating socioeconomic and racial disparities on premature cancer deaths, Figure 1. *Cancer Statistics*. 2011 10.3322/caac.20121
2. Bjurlin MA, Meng X, Le Nobin J, et al. Optimization of prostate biopsy: the role of magnetic resonance imaging targeted biopsy in detection, localization and risk assessment. *J Urol*. 2014; 192(3):648–658. [PubMed: 24769030]
3. Van de Ven WJM, Barentsz JO. MRI/US-guided biopsy—a viable alternative to TRUS-guidance. *Nat Rev Urol*. 2013; 10(10):559–560. [PubMed: 23938941]

4. Siddiqui MM, Rais-Bahrami S, Truong H, et al. Magnetic resonance imaging/ultrasound-fusion biopsy significantly upgrades prostate cancer versus systematic 12-core transrectal ultrasound biopsy. *Eur Urol*. 2013; 64(5):713–719. [PubMed: 23787357]
5. Pokorny MR, de Rooij M, Duncan E, et al. Prospective study of diagnostic accuracy comparing prostate cancer detection by transrectal ultrasound-guided biopsy versus magnetic resonance (MR) imaging with subsequent MR-guided biopsy in men without previous prostate biopsies. *Eur Urol*. 2014; 66(1):22–29. [PubMed: 24666839]
6. Jung AJ, Westphalen AC, Kurhanewicz J, et al. Clinical utility of endorectal MRI-guided prostate biopsy: preliminary experience. *J Magn Reson Imaging*. 2014; 40(2):314–323. [PubMed: 24924999]
7. Al-Hweish AK, Abdul-Rehman IS. Outpatient percutaneous renal biopsy in adult patients. *Saudi J Kidney Dis Transpl*. 2007; 18(4):541–546. [PubMed: 17951940]
8. [Accessed August 7, 2014] ACR Practice Guideline for the Performance of Magnetic Resonance Imaging-Guided Breast Interventional Procedures Res 26 –2011. http://www.acr.org/~media/ACR/Documents/PGTS/guidelines/MRI_Guided_Breast.pdf
9. Blumenfeld P, Hata N, DiMaio S, et al. Transperineal prostate biopsy under magnetic resonance image guidance: a needle placement accuracy study. *J Magn Reson Imaging*. 2007; 26(3):688–694. [PubMed: 17729363]

Fig. 1.

A Oblique axial T2-weighted MR image obtained during direct MRI-guided biopsy in a 68 year old man with a persistently elevated serum prostatic specific antigen level of 6.2 ng/mL and two prior negative standard transrectal ultrasound-guided biopsies (patient #2 in Table 2) shows an ill-defined focus (*arrow*) of low T2 signal intensity in the left apex anteriorly. **B** Oblique axial T2-weighted MR image obtained 9 min after two core biopsies of the target lesion demonstrates a linear track (*arrows*) of tissue signal distortion along the expected path of the needle, and traversing the target. Note that the needle sleeve is now pointing toward the right, because these images were obtained during targeting of a separate lesion in the *right apex*. **C** Oblique axial T2-weighted MR image obtained 7 min after (**B**) and 16 min after biopsy shows that the needle track distortion has resolved. Final pathology demonstrated Gleason 4+4 cancer in the cores from the *right apex* and benign tissue in the cores from the *left apex*.

Fig. 2.

A Oblique axial T2-weighted MR image obtained during direct MRI-guided biopsy in a 58 year old man with a rising serum prostatic specific antigen level of 35.2 ng/mL and three prior negative transrectal ultrasound-guided biopsies (patient #9 in Table 2) shows an ill-defined focus (*arrow*) of low T2 signal intensity in the central gland at the right base. **B** Oblique axial T2-weighted MR image obtained 3 min after two core biopsies of the target lesion demonstrates a linear track (*arrow*) of tissue signal distortion along the expected path of the needle, and traversing the target. **C** Photomontage of progressively delayed oblique axial T2-weighted MR images obtained 8 (*left image*), 20 (*middle image*), and 34 (*right image*) minutes after the target biopsies show the needle track (*arrows*) is of decreased conspicuity at 8 and 20 min and no longer visible by 34 min. Note that the needle sleeve is not visible, because these images were obtained during targeting of a separate lesion more inferiorly in the *left apex*. Final pathology demonstrated Gleason 3+4 cancer in 100% of the cores from the right base and Gleason 3+4 cancer in 75 of the cores from the *left apex*.

Table 1

Diagnostic endorectal multiparametric MRI protocol used to identify targets for direct MRI-guided prostate biopsy

Parameter	T1	T2	Diffusion	Perfusion
Sequence	Axial fast spin echo	Axial & coronal fast spin echo	Axial single-shot echoplanar	Axial steady-state gradient echo
Anatomic coverage	Pelvis	Prostate	Prostate	Prostate
TR/TE (ms/ms)	400–600/10	Minimum/120	minimum/minimum	Minimum/minimum
Echo train length	4	26	NA	NA
PI acceleration factor	1.6	1.3	2	4
Matrix	352 × 352	560 × 560	176 × 176	232 × 168
Field of view (cm)	30	18	18	18
Number of excitations	2	3	3	
Slice thickness/gap (mm)	5/0.5	3/0	3/0 × 25	3.2/0 × 20
Specific to sequence	Transverse frequency direction	Anteroposterior frequency direction for axials	B values of 0, 600, and 1000 s/mm ² (ADC maps created and exported to PACS) Frequency-selective inversion recovery fat suppression	Flip angle = 150°, 35 phases pre/post of 20 cm ³ IV gadodiamide (Omniscan; GE Healthcare, Milwaukee, WI) injected at 3 cm ³ /s. Post-processed multiparametric perfusion maps for relative enhancement, maximum enhancement, maximum relative enhancement, time of contrast media arrival (T0), time to peak, wash in rate, wash out rate, brevity of enhancement, and area under the curve created on an independent workstation (IntelliSpace Portal; Philips Healthcare, Netherlands and exported to PACS

Studies performed on a 3T whole-body MR scanner (Ingenia or Achieva; Philips Healthcare, Netherlands) with patients in the supine position using a body coil for signal excitation and a flexible multi-element phased-array surface coil (Philips 32 channel SENSE Torso/Cardiac coil) combined with a balloon-covered expandable endorectal coil (Medrad Prostate eCoil) inflated to 80–100 cm³ for signal reception (all MR images were routinely post-processed to compensate for the reception profile of the coils)

Clinical and imaging characteristics of the 8 patients in the study group undergoing MRI-guided prostate biopsy

Table 2

	Age (years)	PSA (ng/mL)	Reason for MRI-guided biopsy	Target diameter (mm)	Time to post-biopsy imaging (min)	Needle track visible	Time to delayed post-biopsy imaging (min)	Needle track visible on delayed images	Biopsy result
1	71	7.2	Declined standard systematic biopsy	21	15	Yes	25 & 33	Less visible	G3+3 in 25%
2	68	6.2	Two prior negative standard transrectal ultrasound-guided biopsies	12	9	Yes	16	Not visible	G4+4 in 5%
3	73	14.0	Recent transrectal ultrasound-guided biopsy demonstrating Gleason 3+3 cancer in 2 of 9 cores; concern for greater disease	31	4	No	NA	NA	Benign
4	68	5.8	On active surveillance for Gleason 3+3 cancer on standard transrectal ultrasound-guided biopsy. Disease re-evaluation	14	10	Yes	16	Not visible	G3+3 in 50%
5	76	5.6	On active surveillance for Gleason 3+3 cancer on standard transrectal ultrasound-guided biopsy. Disease re-evaluation	17	4	Yes	NA	NA	G3+4 in 50%
6	60	13.0	Two prior negative standard transrectal ultrasound-guided biopsies	18	5	Yes	NA	NA	Benign
7	75	12.0	Two prior negative standard transrectal ultrasound-guided biopsies	17	5	Yes	16	Not visible	Benign
				7	3	Yes	NA	NA	Benign
8	69	8.8	On active surveillance for Gleason 3+3 cancer on standard transrectal ultrasound-guided biopsy. Disease re-evaluation	14	3	Yes	NA	NA	G3+4 in 20%
9	58	35.2	Rising PSA with three prior negative standard transrectal ultrasound-guided biopsies	28	3	Yes	8, 20 & 34	Less visible	G3+4 in 100%
				13	6	No	NA	NA	G3+4 in 75%