MR/US Fusion Imaging as an Aid to Prostate Biopsy

- The current method of diagnosing prostate cancer is US-guided systematic sextant biopsy of each lobe of the prostate gland with no specific lesion target
- Multiparametic MRI (anatomic, diffusion-weighted, and perfusion imaging) can identify the presence of a lesion and estimate its clinical relevance
- Three-dimensional reconstructions of the MR images can be created and fused with real-time US images during prostate biopsy to target the suspicious lesion
- MR/US fusion-guided prostate biopsy improves the accuracy of detecting high-grade tumors, while minimizing overdetection of low-grade tumors

*E*ach year an estimated one million men in the US undergo a prostate biopsy to diagnose suspected prostate cancer, leading to the diagnosis of 230,000 cases per year. The standard method uses US guidance, which is notoriously unreliable for detecting prostate cancer. Therefore, biopsy samples are taken in a systematic manner from multiple standard sites throughout the prostate. Of the cancers detected by this method, many are indolent and unlikely to lead to death. At the same time, the false-negative rate of US-guided biopsy has been estimated to be as high as 35%.

MRI is an effective way to visualize prostate tumors. It is currently used to stage prostate cancer and assess the suitability of low-risk tumors for active surveillance. It is also used in some cases when prostate cancer is suspected, but US-guided biopsies are negative.

Multiparametic MRI combines anatomic, diffusion-weighted (DWI), and dynamic contrast-enhanced (DCE) imaging (Figure 1). Anatomic imaging provides the highest spatial resolution images in which tumors appear as low-signal intensity areas in T2-weighted images. DWI measures differences in the random Brownian motion of water, or diffusion, which is more rapid in the normal gland than in tumors because of the high cellularity of tumors. DCE MRI takes advantage of differences in the vascularity of tumors and normal tissue. Due to angiogenesis, vascularity is higher in tumors than in surrounding tissue, resulting in higher rates of uptake and washout of contrast material. A recent meta-analysis indicated that multiparametic MRI has an estimated sensitivity of 0.74 (95% CI, 0.66–0.81), specificity of 0.88 (95% CI, 0.82–0.92), and negative predictive values ranging from 0.65 to 0.94.

MR/US Fusion-Guided Prostate Biopsy

MR/US fusion-guided biopsy depends on the creation of a 3D image of the prostate gland that shows the location, size, and shape of a suspected tumor. This image is created from an MRI performed prior to the biopsy procedure (Figure 2). During procedure, the stored MR image is uploaded into a dedicated device that aligns it with real-time US images (Figure 3). The urologist can then direct the biopsy tool to sample the suspected tumor. The MR/US fusion-guided biopsy device records the precise location of the biopsy site. Subsequent sampling of the same site can be obtained at a later date with an accuracy of within 1–2 mm.

A recent review reported that MR/US fusion-guided biopsies were 2–3 times more sensitive than non-targeted systematic biopsy and that nearly 100% of men with highly suspicious lesions identified by MRI are diagnosed with prostate cancer. Moreover, nearly 40% of men with a Gleason score of at least 7 were diagnosed only with the aid of MR/US fusion guidance.
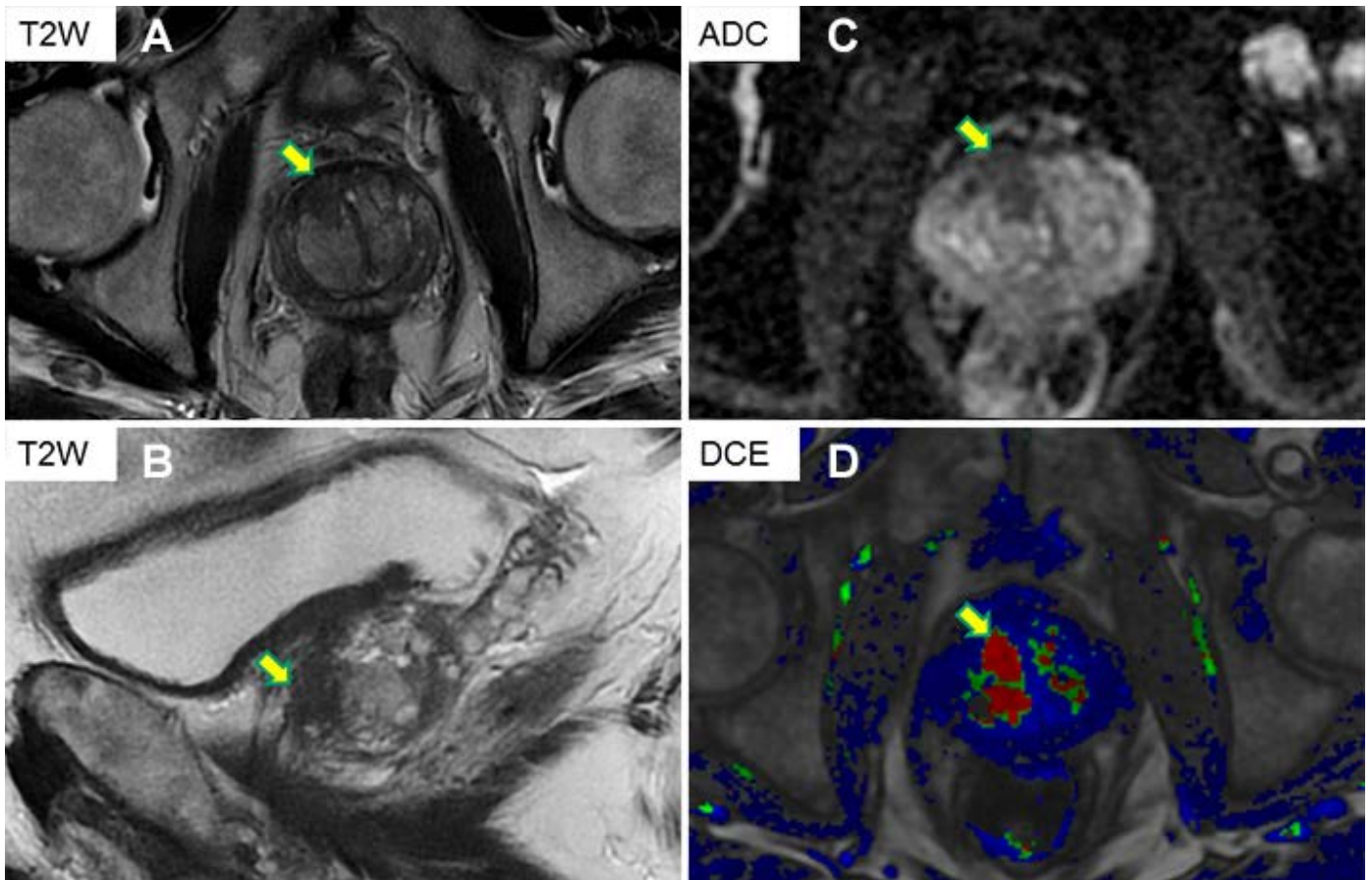
Figure 1. Multiparametric MRI of the pelvis. **(A)** Axial and **(B)** sagittal T2 weighted images show dark areas (arrows) in the prostate gland in high anatomic detail. **(C)** Diffusion weighted image shows reduced diffusion and in **(D)** dynamic contrast enhanced imaging shows greater blood flow (arrow) in the same region, which together are highly suggestive of prostate cancer.
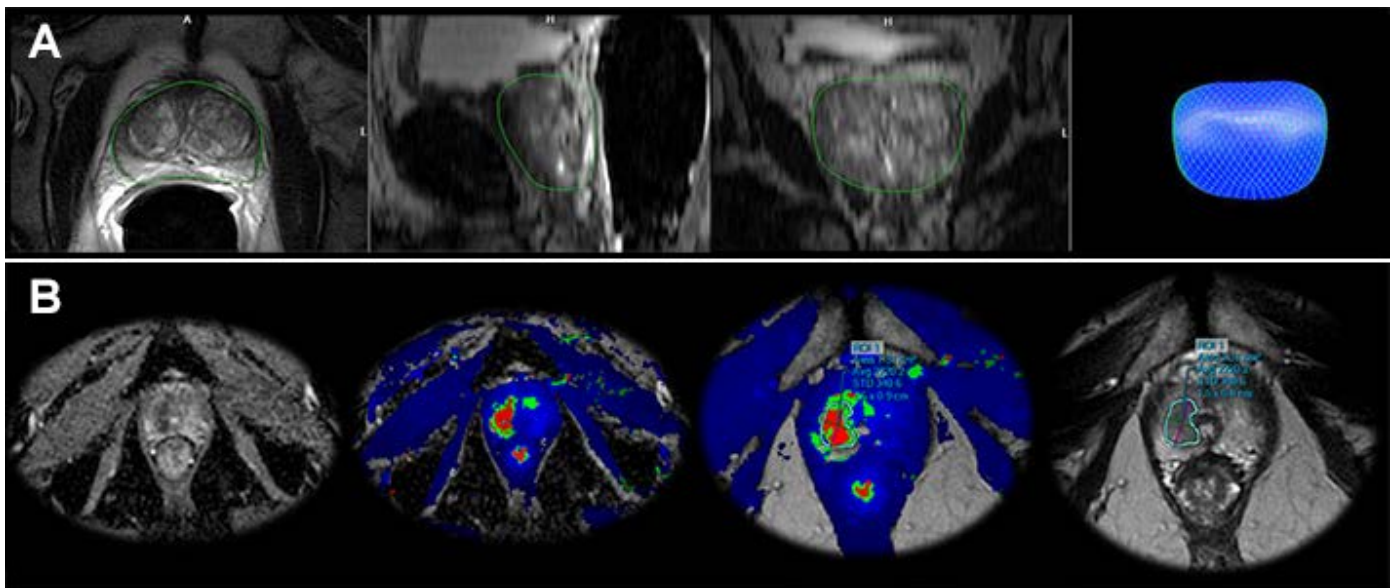

Figure 2. Steps involved in outlining the prostate gland and marking the area of clinically significant tumor. **(A)** T2 weighted MRI of the prostate showing fusion planning with outlining of the prostate grand (green outline). Last picture (blue) is volume rendering of the prostate. **(B)** Diffusion weighted and apparent diffusion coefficient (ADC) images show the tumor (green and red), and outlined (blue outline) on T2 weighted image. (Enlarge Image)

Figure 3. MR/US fusion-guided biopsy. **(A)** US image overlaid with outline of prostate gland (orange line) and the suspected tumor (white line) from MRI. Projected needle target is also shown (green and orange target). **(B)** MR/US fusion image.

A recent prospective cohort study of 1,003 men who underwent concurrent MR/US fusion-guided targeted biopsies and systematic US-guided biopsies showed that targeted biopsies led to the diagnosis of 461 cases of prostate cancer whereas standard systematic sampling biopsies yielded 469 cases. The diagnoses were in agreement in 690 men (69%). Significantly, targeted imaging detected 30% more high-risk cancers (173 *vs.* 122, p <.001) and fewer low-risk cancers (213 *vs.* 258, p <.001). Anterior lesions, which are not always in the range of the standard systematic sampling method, were detected more frequently by targeted MR/US fusion-guided biopsies.

Potential Clinical Implications

It is not yet known whether the use of targeted biopsies will affect the clinical outcomes of patients diagnosed with prostate cancer. However, the current method of systematic biopsy, in which as many as 12 cores may be sampled, can lead to overdetection of small indolent tumors and may underdetect clinically significant tumors. Up to 50% of tumors detected by this method may not be clinically relevant; and although many patients undergo active surveillance, some will undergo prostate cancer treatment unnecessarily. At the same time, 28,000 men die from prostate cancer each year in the US and these numbers might decrease if more high-risk cancers were accurately detected at an earlier stage.

Further studies are necessary to discover if MR/US fusion-guided biopsies will improve the ability to categorize the risk of tumor growth and, on this basis, reserve aggressive treatment for patients at intermediate to high risk while avoiding treatment in patients at low risk.

For men with apparently low-risk prostate cancer who are considering active surveillance, MR/US fusion-guided biopsy can be useful in detecting higher risk clinically significant disease that was undetected by the initial biopsy, identifying men in whom active treatment is more appropriate. Further study is needed to establish the ongoing

role of MR/US fusion-guided biopsy in continued surveillance of appropriately selected low-risk lesions. Because the same site can be sampled repeatedly, MR/US fusion-guided biopsy could be more accurate than standard US-guided biopsy alone.

Scheduling

Multiparametric prostate MRI is performed at the main campus of Massachusetts General Hospital, at Mass General Imaging - Chelsea and Mass General West Imaging - Waltham. These images are then reconstructed into 3D representations that can be fused with real-time US images during subsequent prostate biopsy. Appointments for multiparametric prostate MRI can be made through ROE (inside Partners network) or ROE Portal (outside Partners network) or by calling 617-724-XRAY (9729).

Further Information

For further information on multiparametric prostate MRI systems and 3D image reconstruction, please contact Mukesh Harisinghani, MD, Abdominal Imaging Division, Department of Radiology, Massachusetts General Hospital, at 617-726-8396.

For further information of MR/US fusion-guided biopsy, please contact Adam Feldman, MD, MPH, at 617-643-1955.

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