Associate Professor David A. Woodrum, M.D., Ph.D. is a board-certified radiologist with advanced fellowship training in Interventional Radiology and MR Imaging from the Mayo School of Graduate Medical Education at the Mayo Clinic College of Medicine. He completed his residency in Diagnostic Radiology, as well as a preliminary residency in Internal Medicine, through programs in Rochester at the same institution. Prior to his specialty training, he completed an internship in Internal Medicine at Mayo Clinic.

Dr. Woodrum researches the molecular cell signaling mechanisms of tumor resistance to thermal ablation and new techniques for MRI-guided thermal ablation. His specialty is interventional radiology, with an emphasis on oncology treatment and MRI interventions. He has a background in physics, cellular biology and interventional radiology.

MRI: The Next Frontier in Interventional Radiology

Interventional radiology (IR) has always centered on delivering precision medicine through targeted therapy using the most accurate imaging guidance with the least invasive techniques. Over the past 15 years, I have seen a translation of IR procedures from fluoroscopy-based guidance to the incorporation of ultrasound and CT in a bid to enhance the precision of guidance for the procedures being performed. MRI guidance for procedures offers the next frontier in imaging guidance, with unprecedented lesion conspicuity and treatment monitoring capabilities. In my own clinical practice, MRI has continually enhanced or created the image-guidance platform to enable procedures that were extremely difficult or even impossible with other imaging platforms. What began as a small number of exploratory MRI-guided procedures performed off-hours has evolved into a high-volume, multidisciplinary interventional MRI (iMRI) program encompassing hepatic, prostatic, renal, and musculoskeletal procedures [1].

A personal perspective on the evolution of MRI guidance

This editorial offers a personal perspective on that evolution, written from the viewpoint of a clinician who performs MRI-guided interventions on a near-daily basis. MRI fundamentally changes how one approaches procedural targeting and monitoring. The proceduralist quickly recognizes the fact that if you can see it, then you can target it. Additionally, if you can precisely see what is happening from a treatment/ablation standpoint, then you can quickly tailor your approach to maximize treatment effect while minimizing collateral damage. If we can target and monitor very accurately, then we can treat more precisely with a minimal side-effect profile. This is and always has been the IR mentality. MRI becomes the next tool to advance this philosophy. What previously felt like limitations, such as blurred lesion margins on CT, invisible targets under ultrasound, or repeated needle repositioning, now appear as unnecessary compromises. MRI guidance not only offers superior targeting and monitoring, but with innovative integration with ultrasound and fluoroscopy, it offers the possibility of a “true” multimodality procedure suite which delivers on making the impossible possible for the patient.

Expanding the clinical scope of iMRI

We initially focused on MRI-guided biopsies of lesions that were poorly visualized on CT or ultrasound, particularly in the liver and pelvis. However, we quickly expanded to recurrent prostate cancer after surgery and/or radiation, due to limited treatment options for these patients. This

represented an expansion driven by clinical need, which is what exemplifies the driving force behind the use of MRI guidance. MRI guidance is not replacing US or CT guidance; rather, it is creating procedures which did not exist or were not feasible previously.

As our confidence and operational efficiency grew, we broadened the scope of our procedures to include a full spectrum of thermal ablations (i.e., laser, microwave, and focused ultrasound) and complex interventions requiring precise targeting (i.e., at the scale of a few millimeters) and monitoring secondary to associated collateral sensitive structures. We have successfully guided cryoablation probes into renal tumors adjacent to the bowel, treated centrally located hepatocellular carcinomas with millimetric precision, and performed prostate ablations with submillimeter accuracy, all under real-time MRI visualization.

Precision targeting in prostate and liver interventions

Among the organs we treat, prostate and liver are the most common. In the prostate, MRI is essential for diagnosis in native and recurrent disease. It is therefore a logical conclusion that we would need MRI guidance for the most precise targeting and monitoring of treatment. In the liver, MRI is recognized as the most sensitive imaging platform for the diagnosis of liver lesions. However, with MRI-guided intervention, we no longer must wait for the 3–5 mm lesions to get bigger for biopsy or intervention. We can accurately target and treat these lesions while they are still tiny, potentially impacting the overall progression. While CT continues to play a valuable role for lesions > 1 cm, MRI opens up a new range of treatment options in the < 1 cm category. Additionally, the MRI monitoring capabilities are essential in the prostate, where we are trying to preserve urethra and nerve bundles as well as ureters, bladder wall, and rectum. Working in the confined region of the pelvis with so many immediately adjacent structures that must be preserved has driven the need for MRI guidance for targeting and, more importantly, for monitoring the ablation treatment. In the liver, the importance of monitoring is driven by the need for accurate marginal coverage of the target lesion, especially with the negatively competing vasculature, and by the need to monitor adjacent structures such as bowel, gallbladder, and heart. These capabilities offer the possibility of new patient treatment options with fewer side effects and better outcomes. A recent comparative study of CT-guided versus MRI-guided liver biopsies for focal lesions under 2 cm reinforced what many of us observe in clinical practice: MRI-guided interventions achieved higher diagnostic yield, smaller mean lesion size, and fewer complications, thus highlighting their suitability for high-risk, high-precision cases. These results underscore the clinical added value of MRI in procedural medicine, especially in oncology, where lesion conspicuity and precision are paramount [2].

Overcoming barriers to adoption

However, broader adoption of iMRI still faces barriers. In many centers, MRI continues to be viewed primarily as a diagnostic resource, and logistical challenges (scanner access, team training, MR safety, and lack of interventional protocols) can hinder progress, as shown in the past. This is where recent technological innovations play a pivotal role.

Reimbursement: A critical piece of the puzzle

Reimbursement is an essential part of any procedure. As we look to expand the role of MRI guidance, this must be acknowledged and tackled. Currently, many iMRI procedures fall into ambiguous or under-recognized billing categories, which can disincentivize their use despite the strong clinical evidence, especially when viewed in competition with well-recognized diagnostic reimbursement codes. More dedicated MR procedural codes are necessary, and making these changes will require a combined approach from corporate partners, physician proceduralists, and national medical societies. Clearer procedural coding and appropriate reimbursement models that align with the actual clinical effort, equipment, and infrastructure involved will be essential to support the adoption of iMRI on a broader scale. As more data on outcomes emerge, particularly regarding complication rates, patient safety, and long-term cost savings (e.g., fewer repeat procedures or hospital readmissions), the case for reimbursement reform becomes even stronger.

The role of MRI in surgical settings

Beyond percutaneous interventions, MRI is increasingly being incorporated into surgical settings in the brain and, more recently, in complex pelvic tumors. Urologic surgeons are utilizing MRI guidance for resections and intraoperative margin assessments, particularly in complex pelvic tumors [3]. Looking ahead, this pattern will likely continue as MRI will become more deeply integrated, offering real-time image guidance during resection and reconstruction to make the surgical procedures even better than they are currently. The underlying technology exists; the next step

is to refine the workflow and achieve broader clinical adoption. None of this is possible without multidisciplinary collaboration, as iMRI relies on tightly coordinated teams of radiologists, technologists, anesthesiologists, and nursing staff. Institutional support is essential, particularly in areas such as equipment acquisition, procedure scheduling, and reimbursement infrastructure. However, once these foundational elements are in place, the clinical benefits of iMRI become clear and difficult to overlook. In our department, iMRI is no longer viewed as an experimental or niche capability; it is an essential part of our clinical interventional oncology practice and it continues to grow.

The rise of low-field MRI systems

The introduction of low-field MRI systems, particularly 0.55T, is facilitating a fundamental shift. These systems are enabling greater technological integration and allowing more conventional interventional workflows. They offer easier adoption across the board and provide wide bores, improved patient access, and lower infrastructure costs. Most importantly, the image quality for procedural guidance is comparable to that of 1.5T, particularly when using modern image reconstruction techniques enhanced with AI technology. Continued evolution of the imaging capabilities at lower field (0.55T) is essential for providing sufficient spatial and contrast resolution for targeting and real-time monitoring, even in technically demanding cases. All of this together makes 0.55T MRI an ideal platform for institutions looking to establish or scale iMRI services without disrupting diagnostic throughput.

Industry collaboration and technological integration

The growing availability of MRI-compatible interventional tools, from ablation applicators to biopsy devices and guidance systems, is addressing a key practical limitation. Industry collaborations are accelerating progress in this area. The strategic partnership between Siemens Healthineers and Cook Medical, for instance, is focused on codeveloping MR-compatible procedural devices and seamless workflows that support safe, efficient, and reproducible interventions. This type of alignment between imaging technology and therapeutic tools is critical for transforming iMRI into a scalable and sustainable clinical solution.

Starting an iMRI program: Practical recommendations

For colleagues and institutions considering the integration of iMRI into their practice, my recommendations are straightforward:

1. Start with a clear need for MRI with the lesions that are difficult to visualize on CT or ultrasound for biopsy and/or ablation.
2. Consider patients for whom repeated radiation exposure is a concern.
3. Train a specialized team of MR technicians, nurses, and physicians to maximize procedural success and safety. Although there are fewer safety constraints with lower-field MRI (0.55T), they are still omnipresent within the MRI suite.

With the appropriate tools and infrastructure, it becomes readily apparent that MRI does not merely assist with image guidance; it transforms it. We are entering a new chapter in image-guided and radiation-free therapy, and MRI is central to that evolution. It offers the precision we have always sought, the safety our patients increasingly expect, and the procedural control necessary to deliver the best-possible outcomes. For those of us already performing a high volume of iMRI-guided interventions, this is no longer an emerging technology. It is the new standard we hold ourselves to today.

David Woodrum

References

1 Thompson SM, Gorny KR, Koepsel EMK, Welch BT, Mynderse L, Lu A, et al. Body Interventional MRI for Diagnostic and Interventional Radiologists: Current Practice and Future Prospects. Radiographics. 2021;41(6):1785–1801.
2 Schmidt VF, Öcal O, Walther V, Fabritius MP, Dietrich O, Kazmierczak PM, et al. Clinical benefits of MRI-guided freehand biopsy of small focal liver lesions in comparison to CT guidance. Eur Radiol. 2024;34(9):5507–5516.
3 van Luijtelaar A, Fütterer JJ, Bomers JG. Minimally invasive magnetic resonance image-guided prostate interventions. Br J Radiol. 2022;95(1131):20210698.