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Editorial

Insights into innovative breast imaging techniques

Our work as radiologists is inextricably entwined with technology. Without William Roentgen's discovery of X-rays and systematic study of their utility, our medical subspecialty would not exist in its current form. As imaging technology has grown, so, too, has the field of radiology. Scientific innovation has driven technological advances and vice versa, a wondrous circle that provides the tools for more robust medical imaging, better understanding of human physiology and pathophysiology, and better patient care. As radiologists, we are uniquely qualified not only to use the technology handed to us, but to help refine, improve, and make it better suited to our clinical needs as well as those of our medical and surgical colleagues. We can even help to drive new development and push technology in the most clinically useful direction. In order to do this, we must be experts in our tools. We must understand the technology that we use and know its strengths and weaknesses. We must see its limitations in order to derive the most out of it and practice responsibly.

The accompanying papers on breast tissue markers by Shah et al. and on the principles and artifacts of breast tomosynthesis by Sujlana et al. highlight two important tools of our trade. The advent of percutaneous needle biopsy as a feasible and preferable alternative to surgical excisional biopsy revolutionized the practice of breast imaging in the early 1990s. At the same time, it posed a clinical challenge. What were surgeons and radiologists to do if the needle biopsy removed the imaging target entirely and the pathology was malignant or high risk? Initially, leaders in the field recommended that percutaneous biopsy only be used for lesions larger than 5 mm [1,2], such that a portion of the target could reliably be left behind. Further innovation was required to make percutaneous biopsy a reasonable and wise choice for even the smallest of lesions. In response to this clinical dilemma, a 15-gauge, 2 × 2 mm, percutaneous metallic marker clip was developed (MicroMark; Biopsys Medical) and approved for use by the US Food and Drug Administration in 1995 [3]. The introduction of the biopsy marker clip, now a staple of every breast imaging practice, was a critical step in the practice-changing widespread adoption of percutaneous biopsy.

The work of a Dutch researcher, Ziedses des Plantes, in the early 1930s laid the theoretical groundwork for modern tomosynthesis. His work could not be practically implemented until many decades later because the technology did not exist to realize it. In the 1960s and 1970s, many worked on bringing tomosynthesis into clinical practice, but there remained many practical barriers in spite of relevant technological advancements. When computed tomography became widely accepted in the late 1970s, interest in tomosynthesis declined. However, the critical technological barriers were overcome in the late 1990s, and what was considered a very old technology became new and relevant again. First, the necessary computing became practically feasible due to declining processing costs. Second, digital flat-panel detectors were developed that enabled the rapid creation of high-quality digital images. Radiologists practicing breast imaging knew well the limitations posed by overlapping tissue in mammographic interpretation, so the technology seemed well suited to this clinical challenge [4]. The collaboration between those radiologists with clinical expertise and researchers with the relevant scientific know-how created one of the greatest leaps forward in breast imaging in recent years. As clinical experts, we are able to help point the research in the right direction and optimize it for our clinical needs.

Innovation in medical imaging comes not just from the invention of new tools or techniques, but also from new applications for the tools that we have. A bit of flexible thinking and problem solving may allow for novel uses of older applications. For example, the authors of the accompanying paper on tissue markers highlight the various uses for biopsy marker clips, devices that were originally developed for the singular purpose of marking lesions no longer visible following biopsy [5]. Today, biopsy marker clips are useful in a wide range of circumstances, many of which were likely unforeseen at the time of their development. In our practice, the localization of pathology-proven malignant axillary lymph nodes that have undergone subsequent treatment with chemotherapy has recently become a novel challenge posed by our breast surgeons. Our surgeons now routinely perform targeted axillary dissections following neoadjuvant chemotherapy, and thus we are routinely asked to identify and localize a lymph node that was biopsied months before and is often, at the time of requested localization, completely normal in appearance. As shown in the recent work by Dashevsky et al., finding the biopsied lymph node after it has normalized in appearance can be virtually impossible. In their population, the incorrect lymph node was localized in 7% of cases (2/28), even with a biopsy marker clip in place, due to poor sonographic visibility of the clip [6]. After many struggles and a few failed attempts, we have adopted the routine placement of hydrogel embedded biopsy marker clips in biopsied axillary lymph nodes.

Our enthusiasm for new technology should not hamper our support of its thorough investigation in the clinical setting. No technology is perfect, and understanding the limitations allows us to optimize its performance. Sujlana et al. not only educate us in the fundamentals of tomosynthesis, but also provide us with a practical guide to the artifacts we may encounter in our day to day practice. Being able to recognize these entities in our practice may eliminate the need for additional images in many cases. Thankfully, solid clinical research has done the important work of thoroughly assessing this new imaging modality in real life clinical settings, artifacts and all. From such research, we have learned that tomosynthesis decreases false positive call back rates by 6 to 67% as compared to 2D-mammography [7–10], tomosynthesis and 2D mammography together increase cancer detection rate by 9.5% compared to digital mammography alone [11], and that synthetic 2D mammograms have similar performance to standard 2D mammograms

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[12–15] such that a separate 2D acquisition is likely unnecessary. In order to realize the same results in our own practices that we see published in the literature, we must understand the shortcomings of our equipment and be able to recognize its pitfalls.

There is a growing understanding of breast cancer as a very heterogenous disease, and therapy tailored to the specifics of a patient's tumor is becoming the norm. In our research, we are looking to meet a growing clinical need for more detailed information about patients' tumors before they are surgically excised, down to their very genetic makeup enabling precision medicine. Precision medicine personalizes therapy on an individual basis with a host of targets, including genes and their transcripts, proteins, and metabolites [16–19]. Aided by recent advances in artificial intelligence, radiogenomics, which combines genetic and radiomic data, may further provide voxel-by-voxel genetic information for an individual heterogeneous tumor to guide tailored therapy [16–19]. Just as all imaging technology that has come before, the exciting field of radiogenomics is flourishing in the hands of clinical and scientific collaborators with the common goal towards precision medicine.

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