Following the inception of mammography (MG) for screening purposes in the early 1960s, the field of breast imaging has undergone a transformative progression. This evolution gathered significant momentum by incorporating ultrasound (US) and image-guided biopsies into routine clinical practice during the 1990s. Multimodality and multiparametric imaging have firmly established breast radiology's pivotal role in managing breast disorders. A shift from conventional to digital radiology emerged in the late 20th and early 21st centuries, enabling advanced techniques like digital breast tomosynthesis, contrast-enhanced mammography, and artificial intelligence (AI) integration. AI's impending integration into breast radiology may enhance diagnostics and workflows. It involves computer-aided diagnosis (CAD) algorithms, workflow support algorithms, and data processing algorithms. CAD systems, developed since the 1980s, optimize cancer detection rates by addressing false positives and negatives. Radiologists' roles will evolve into specialized clinicians collaborating with AI for efficient patient care and utilizing advanced techniques with multiparametric imaging and radiomics. Wearable technologies, non-contrast MRI, and innovative modalities like photoacoustic imaging show potential to enhance diagnostics. Imaging-guided therapy, notably cryotherapy, and theranostics, gains traction. Theranostics, integrating therapy and diagnostics, holds potential for precise treatment. Advanced imaging, AI, and novel therapies will revolutionize breast radiology, offering refined diagnostics and personalized treatments. Personalized screening, AI's role, and imaging-guided therapies will shape the future of breast radiology.

**Key Points**
- Advancing integration of artificial intelligence (AI): AI is becoming integral to breast radiology, streamlining workflows, smart dataprocessing, aiding detection and diagnosis, and optimizing decision-making processes.
- Personalized screening and diagnosis: Evolving from mammography, automated breast ultrasound, magnetic resonance imaging (MRI), and contrast-enhanced mammography offer personalized screening options with AI-driven enhancements for accuracy.
- Innovative imaging and therapies: Multiparametric MRI, virtual biopsy, and photoacoustic imaging provide advanced diagnostic insights. Imaging-guided therapies and theranostics promise targeted precision treatment, transforming breast radiology's future.

Following the inception of mammography (MG) for screening purposes in the early 1960s, the field of breast imaging has undergone a transformative progression. This evolution gathered significant momentum by incorporating ultrasound (US) and advanced image-guided biopsies into routine clinical practice during the 1990s. Subsequently, in the early 2000s, magnetic resonance imaging (MRI) emerged as a discriminating option for advanced imaging modalities. Furthermore, the shift from conventional to digital radiology occurred between the late twentieth and early twenty-first centuries. Concerns mainly revolved around the reduced resolution of digital images compared to conventional MG, which raised worries about potentially missing lesions like microcalcifications and the challenge of detailed breast tissue visualization. Nevertheless, due to the broader dynamic range of digital MG compared to screen-film MG, it displayed greater tolerance to exposure errors. Additionally, the digital format of images offered a significant advantage, allowing for the integration of advanced techniques. This, in turn, facilitated the incorporation of digital breast tomosynthesis imaging, contrast-enhanced MG, and artificial intelligence (AI) applications. Subsequently, in the early 2000s, MRI emerged as a discerning option for advanced imaging modalities. Through the assessment of multimodality and multiparametric imaging, breast radiology has indisputably established itself as an indispensable and irreplaceable component in the management of breast disorders.
From Volume Screening to Personalized Screening

Screening in breast cancer, which began as a simple MG examination and has now evolved to a personalized screening approach. A better understanding of the significance of breast density has led to a change in screening strategies for women with dense fibroglandular tissue, driven by heightened awareness of its influence on false negatives and elevated breast cancer risk. Supplementary US screening is widely used for women with dense breast tissue. A recent large, randomized US screening study showed the impact of ultrasonography in detecting two additional cancers per 1000 women, in line with previous studies (17). However, US encounters significant limitations, including its real-time nature and user-dependent operation, leading to archiving and retrospective analysis challenges. Automated breast ultrasound system (ABUS) can be used for screening and diagnostically, providing a 3-dimensional volume view (18). Undoubtedly, AI algorithms to be developed in the future will enable better visualization of this 3D data, facilitate lesion detection with CAD solutions, and allow faster evaluation with decision support algorithms. Since ABUS can also help teleradiology, US scanning can be performed where radiologists are unavailable. Research continues on automated US imaging with a tomography mechanism by allowing the breast to sag with gravity in the prone position instead of the supine position (19). In this way, it will be possible to evaluate other parameters, such as speed of sound, which may show higher specificity in lesion differentiation (20).

Breast MRI is also valuable as a supplementary screening tool and is effective not only in high-risk women but also in women with average risk but increased breast density (21). Furthermore, a recent randomized controlled MRI screening study included women with extremely dense breast tissue from a national breast cancer screening program. These women were offered supplementary MRI screening every two years, resulting in a notable reduction in interval cancers and the detection of an additional 15 cancers per thousand screenings (22). However, breast MRI is expensive and hard to access as a large-volume screening method. Contrast-enhanced MG can be an excellent alternative to MRI and offers a cost-effective and convenient solution for screening high-risk women and those with dense breast tissue (23, 24). This approach has the potential to facilitate efficient and rapid large-scale female screening.

Wearable technologies, such as specialized bras equipped with US sensors, can potentially transform follow-up and screening approaches (25). Meanwhile, non-contrast MRI techniques are gaining traction, providing valuable information, particularly in screening without invasive contrast agents. Combining T2-weighted or STIR images with diffusion imaging can provide comparably high-sensitivity results to contrast-enhanced MR scanning (26, 27). Future advancements aim to enable rapid, non-contrast breast MRI scans, suitable even for women with contrast contraindications.

Innovations in Diagnostic Imaging

The cornerstone of breast MRI examination is dynamic contrast-enhanced imaging. MRI, highly sensitive in breast radiology, evaluates multiple parameters such as diffusion-weighted imaging, spectroscopy, and dynamic contrast enhancement (28-30). Through multiparametric MRI, neovascularization, tissue water diffusion, and molecular markers can be assessed enabling molecular-level imaging (31). Tumor characteristics like proliferation, angiogenesis, apoptosis, metabolism, and hypoxia can also be demonstrated (31). Dynamic contrast-enhanced MRI depicts contrast material kinetics, quantifying neovascularization via tumor perfusion. Excessive tumor cell
pulmonary or cryogenic treatments, interventional radiology is a field that has emerged as a vital component of breast cancer management. Some of the key challenges include the need for precise lesion localization and accurate procedural guidance. The development of imaging-guided therapies has been transformative, offering improved diagnostic accuracy and therapeutic outcomes.

**Imaging-Guided Therapy**

Cryotherapy is a method that can be applied with US guidance and has been recently researched to treat breast cancer. A pivotal study on this subject is the ICE3 study, in which 194 women over 60 were evaluated, and the tumor size ranged from 8-14.9 mm. In a mean follow-up of 3 years after treatment, ipsilateral tumor recurrence was 2.06% (47). Cryotherapy holds promise as a viable alternative treatment avenue, particularly for instances wherein surgical intervention is not feasible.

Theranostics is derived from therapy and diagnostics and can be defined as using diagnostic methods to provide targeted therapy. Modern breast cancer treatment is optimally individualized and targeted, and theranostics appears to be an excellent method to achieve this goal. In theranostics, the active therapeutic substance will be delivered to the target cell without affecting the surrounding healthy tissues, and the process will be monitored with imaging guidance. The basic procedure is to load the lethal dose to the contrast agent carriers, monitor the agent with imaging, and control the release of the therapeutic agent loaded to the contrast agent into the tumor with the help of imaging methods when it reaches the tumor tissue. For example, after loading the chemotherapeutic agent into microbubbles with US contrast, this contrast agent is injected into the patient, and the tumor is monitored under ultrasound (48). After tracking the contrast material reaching the tumor, these carrier microbubbles are deflated with the help of US waves, and the drug is released within the tumor without damaging the surrounding tissue (48). Particles or nanoparticles suitable for imaging modality are used as therapeutic agent carriers. One of the most used particles for MRI are superparamagnetic iron oxide nanoparticles (49, 50). Carbon nanotubes are important carriers for MRI, and targeted molecules such as drugs, contrast agents, antibodies, cell membrane penetrants, and iron oxide nanoparticles can be loaded onto these nanotubes (50). Theranostics will play an important role in targeted precision therapy in the future.

**Conclusion**

In the future, breast radiology will be able to offer more patient-focused diagnosis and treatment approaches, thanks to the developing technological applications and AI’s support to radiologists in every field, from workflow to image formation and CAD systems. Integrating imaging genomics will aid differential diagnosis, aligning genetics with multiparametric features via AI-enhanced solutions. Novel image-guided therapeutic solutions will provide alternative treatment approaches. The future holds enhanced integration of imaging, AI, and innovative therapies in breast radiology. From personalized screening to innovative theranostics, the trajectory of breast imaging is laden with promise, transforming the landscape of breast radiology, and ultimately improving patient outcomes. The future of breast radiology is not one of replacement, but of transformation as technology and human expertise converge to advance patient care to new heights.

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