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Current Status of Ultrafast MRI in Breast Imaging

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Ultrafast Dynamic Contrast-Enhanced (UF-DCE) MRI represents a significant evolution in breast imaging, stemming from the need for faster and more detailed diagnostic capabilities than conventional DCE MRI. The development of UF-DCE MRI has occurred in tandem with advancements in fast MRI scan techniques, enabling the acquisition of kinetic information with a temporal resolution of several seconds in the very early post-contrast phase, crucially without sacrificing spatial resolution. This rapid acquisition allows for the calculation of new kinetic parameters from the time-intensity curve's initial upslope, which are valuable for diagnosis and potentially for predicting treatment response and prognosis.

Initially, the advanced acceleration techniques required for UF-DCE MRI were primarily limited to high-specification MRI scanners in research institutions, hindering its widespread clinical adoption. However, the increasing availability of these sophisticated scanners has allowed UF-DCE MRI to transition from research protocols into routine clinical practice for breast cancer diagnosis and evaluation.

The core of UF-DCE MRI's technical development lies in its acceleration techniques, which broadly fall into three categories:

View-Sharing Technique: including differential subsampling with Cartesian ordering (DISCO), time-resolved angiography with interleaved stochastic trajectories (TWIST), time-resolved imaging of contrast kinetics (TRICKS), and time-resolved angiography using keyhole (4D-TRAK). View-sharing is highly versatile and widely used in UF-DCE MRI.

Conventional Gradient-Recalled-Echo (GRE): UF-DCE accomplished this way is not affected by temporal contamination of the signal, leading to highly reliable signal measurements. However, the acceleration factor is limited, often requiring a reduction in scan range and spatial resolution.

Compressed Sensing (CS): This is an advanced acceleration method that allows for image reconstruction from randomly and highly undersampled frequency domain data. CS excels at providing very high temporal resolution while preserving high spatial resolution by reconstructing images from a minimal subset of k-space and enforcing time-series continuity. It can be combined with parallel imaging to further enhance speed.

A major benefit in clinical practice is its ability to avoid marked or moderate background parenchymal enhancement (BPE). BPE is less prominent in the early phases of UF-DCE MRI, leading to better lesion-to-noise contrast and improved lesion detectability, particularly for patients with significant BPE or premenopausal status. Additionally, UF-DCE MRI enhances the low specificity of abbreviated MRI by providing critical kinetic information from the time-intensity curve's upslope, aiding in diagnosis and treatment evaluation.



The Maximum Slope (MS) and Time to Enhancement (TTE) parameters derived from Ultrafast Dynamic Contrast-Enhanced (UF-DCE) MRI are associated with various pathological characteristics and prognostic markers of breast cancer. In general, higher MS and shorter TTE is associated with invasive cancers, larger tumor size, high Ki-67 index.

The excellent contrast of early-enhancing vessels also provides crucial insights into the detailed pathological structure of tumor-associated vessels, linking hypervascularity to cancer aggressiveness. The large volume of spatiotemporal data generated by UF-DCE MRI will be supported by automated and artificial intelligence-based processing techniques.

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