Published in final edited form as:

Eur J Radiol. 2012 September ; 81(0 1): S109. doi:10.1016/S0720-048X(12)70044-X.

Breast MRI using SWEEP Imaging with Fourier Transform (SWIFT)

Michael T. Nelson*, **John C. Benson**, **Trisha Prescott**, **Curtis A. Corum**, **Angela L. Snyder**,
and **Michael Garwood**

Center for Magnetic Resonance Research, University of Minnesota Medical School, Department
of Radiology, Minneapolis, MN, USA

Purpose

Optimizing and testing Sweep Imaging with Fourier Transformation (SWIFT) for
contemporaneous high spatial resolution morphological and high temporal resolution
Dynamic contrast Enhanced (DCE) breast MRI.

Introduction

SWIFT [1] (SWEEP Imaging with Fourier Transform) is a radially sampled magnetic
resonance imaging (MRI) sequence utilizing gapped frequency-swept pulse excitation with
nearly simultaneous signal acquisition between pulse elements. There is no “echo time” so
signal is nearly always being acquired making SWIFT fast and efficient. High temporal and
spatial resolution is obtainable from the same scan data. Rapid imaging capability as well as
T2* insensitivity make SWIFT desirable for dynamic contrast enhancement. The novel
properties of SWIFT may be utilized clinically to advance breast MR imaging.

Methods and materials

SWIFT is an emerging MR imaging method that combines swept radiofrequency excitation
with nearly simultaneous acquisition of signal in a time-shared mode. Because the same
SWIFT data can be reconstructed into both high temporal resolution dynamic and high
spatial resolution morphological image series, it offers the potential benefit of lower
operational costs due to reduced scan time. In addition, its absence of exposure to ionizing
radiation, smooth gradient trajectories leading to quieter operation, and lack of
uncomfortable breast compression could potentially make it a cost effective alternative to
mammography as a screening tool for breast cancer. In addition, the ultra-short TE (0.01 ms
or less) of SWIFT allows detection of novel short T2 contrast and reduced T2* effects for

*Corresponding author: M.T. Nelson, MD, Center for Magnetic Resonance Research, University of Minnesota Medical School,
Department of Radiology, Minneapolis, MN, USA. mtnelsonrad@comcast.net (M.T. Nelson).

Invited Presentation at Sixth International Congress on MR-Mammography Friedrich Schiller University Jena, Jena, Germany 9/27–
29/2012

Competing interests: SSI Garwood/Nelson/Corum. Stock holder of SSI sold to GE (Oct 2011). The other authors have no conflicts of
interest to report.

arterial input functions and DCE calculations. This, combined with high temporal resolution and motion correctability, contributes to improved accuracy of Ktrans estimates.

To date, a feasibility study has been completed with examples of benign fibroadenoma, DCIS and IDC (invasive ductal carcinoma). All images used two different sized modified single breast SWIFT compatible coils with surface quadrature transmit and two-channel receive; the transition to the use of a SWIFT compatible dual breast coil is in progress.

Discussion

Clinical evaluation of breast lesions with MRI relies on contrast enhancement kinetics and morphology necessitating high temporal and spatial resolution respectively. Most currently utilized MR techniques can only provide high temporal resolution at the cost of diminished spatial resolution and vice versa. The near continuous acquisition of signal with SWIFT allows for extraordinary temporal resolution without sacrificing spatial resolution. Unlike currently available MR techniques, SWIFT demonstrates T2* insensitivity providing more accurate evaluation of dynamic enhancement. SWIFT's ability to provide both high spatial and temporal resolution make it ideal for evaluation of dynamic contrast enhancement which is essential to breast imaging.

SWIFT will allow for better target imaging; high resolution multi-planar images can be obtained from the same scan data. Also, SWIFT can be used in an inhomogeneous magnet such as a dedicated breast magnet. Gapped frequency-swept pulse excitation used in SWIFT make it more quiet than currently available sequences improving the patient experience. Minimal compression is required for SWIFT allowing for a more comfortable patient environment. Finally, the lack of ionizing radiation in MRI makes SWIFT more desirable than other breast imaging techniques when radiation dose is a concern. SWIFT's speed, quietness and lack of ionizing radiation may allow for ultra-fast screening and diagnostic imaging of the breast.

Current and future clinical research will be performed on larger populations with both benign and malignant lesions.

References

1. Idiyatullin D, Corum C, Park JY, Garwood M. Fast and quiet MRI using a swept radiofrequency. *J Magn Reson.* 2006; 181:342–349. [PubMed: 16782371]
2. Idiyatullin D, Corum C, Moeller S, Garwood M. Gapped pulses for frequency-swept MRI. *J Magn Reson.* 2008; 193:267–273. [PubMed: 18554969]
3. Corum C, et al. Breast Morphological and DCE MRI with SWIFT. *Proc. Intl. Soc. Mag. Reson. Med.* 2011; 19:#3094.