

# Identification of Breast Calcification Using MRI

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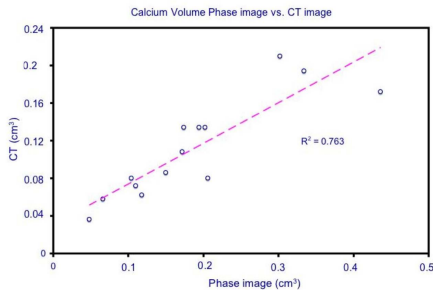
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## Introduction

On conventional MR images, calcifications appear hypointense relative to the surrounding tissue. Due to the diamagnetic property of calcium, optimized phase images obtained using a susceptibility-weighted imaging (SWI) sequence have previously been able to identify brain-associated calcifications. The goal of our current work was to optimize SWI for identification of breast calcification. The clinical detection of micro-calcification is very important in finding and monitoring breast cancer. Furthermore, the standard approach of mammography is not ideal for microcalcification detection in dense breasts.

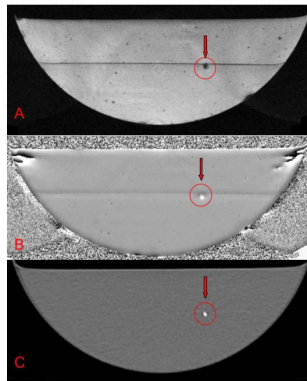
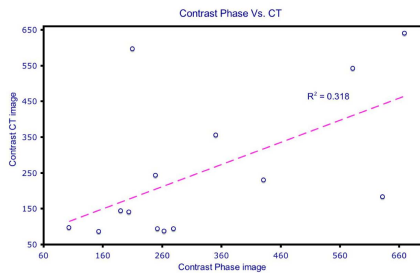
## Materials and Methods

A breast gel phantom having 0.4-0.8mm diameter calcifications (Calcium hydroxyapatite; Sigma Aldrich) was assessed using CT, and MRI. Images were acquired using a



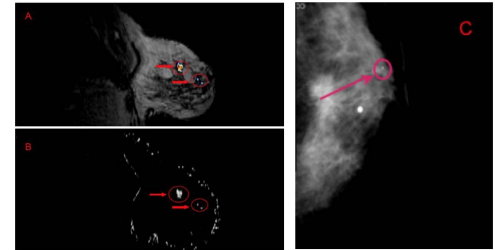
**Figure 1 (above).** Calcification volume comparing CT to MRI SWI phase image. SWI over-estimates the volume approximately by a factor of 2.

**Figure 2 (below).** Image contrast was approximately 25% better for MRI phase images of calcification, compared to CT.



**Figure 3.**

(A) Magnitude SWI image (calcium and air bubbles are similar); (B) Optimized SWI corrected phase image; (C) CT from same slice. Arrow indicates  $\text{Ca}^{2+}$ .



**Figure 4.** (A) Colour SWI positive filtered phase image overlaid on magnitude image; (B) Optimized SWI corrected phase image; (C) X-Ray mammogram. Arrows indicate calcification.

fully flow-compensated 3D SWI sequence using a GE 3T Signa MRI (GE Healthcare, Milwaukee WI) with 8 parallel receivers and a SENSE (ASSET) factor=2, TR/TE=42/30ms, flip=15°, RBW=120Hz/pixel, spatial resolution = 0.4x0.4x2.0mm. The optimum TE for maximum contrast to noise ratio (CNR) in phase images was determined according to:

$$\frac{d\text{CNR}}{TE} = \left( e^{\frac{TE}{T_2}} - \frac{1}{T_2} \times TE \times e^{\frac{TE}{T_2}} \right) = 0 \rightarrow TE = T_2 \quad [1] \quad \frac{(\varphi(x) + \pi)}{\pi}, \text{ for}$$

phases  $\varphi(x) < 0$  and unity otherwise [2]

Using the optimized TE, measurement of calcification volume (**fig.1**) and calcification contrast (**fig.2**) were compared between CT and SWI positive filtered phase (Eqn. 2, above). Finally, we tested whether optimized SWI positive filtered phase data could detect calcification in women who were breast cancer calcification-positive as observed using standard X-ray mammography. Clinical scans were performed using a Vanguard breast imaging system (Sentinelle Medical, Toronto, Canada) and a GE HDX 1.5T MRI system.

## Results and Discussion

Calcifications, as confirmed by CT, were easily identified in the phantom on the optimized SWI phase images (**fig.3**). SWI over-estimated  $\text{Ca}^{2+}$  volume (**fig.3**), however with better contrast than CT (**fig.4**). Human application showed SWI could identify X-ray mammography confirmed calcification (**fig.4**). Calcifications in the phantom were 0.4-0.8mm in size with composition (calcium hydroxyapatite) comparable to that of ductal carcinoma *in situ* (DCIS). Initially a long TE of 78ms (to match T2 [Eqn. 2] was attempted. However this yielded significant aliasing in the phase. To overcome aliasing, we used a TE= 0.5 x T2, which resulted in only a 21.8% reduction of CNR (relative to that seen when TE=T2). Optimized corrected SWI phase images were able to localize breast microcalcifications without ionizing radiation produced by CT and X-ray mammography. With the improved resolution, SNR and proper filtering on high field MRI systems, optimized corrected SWI phase images can be used to confirm microcalcification in breast on conventional MRI. This novel approach will be especially important in women with dense breast tissue.