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Original Article

Diffusion tensor imaging in the normal breast: influences of fibroglandular tissue composition and background parenchymal enhancement☆

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ABSTRACT

Objective: To evaluate effects of fibroglandular tissue (FGT) composition and background parenchymal enhancement (BPE) on diffusion tensor imaging (DTI) parameters in normal breast tissue.
Methods: DTI analysis was performed on 35 breasts with regions of interest drawn to include only normal tissue. Breasts were dichotomized by FGT composition and by BPE; DTI parameters were compared.
Results: The λ_1 principal diffusion coefficient was lower in breasts with moderate/marked BPE versus those with minimal/mild BPE ($P = .039$). All other parameters were unaffected.
Conclusion: λ_1 is sensitive to differences in BPE within normal breast tissue that should be taken into account in DTI evaluation.

1. Introduction

Conventional breast magnetic resonance (MR) imaging is an extremely valuable tool owing to its high sensitivity for breast cancer detection and is widely used in screening high-risk populations and preoperatively [1,2]. It is limited by a specificity of 72% [1]; however, there is ongoing research evaluating ways to improve the specificity of breast MR. Initially, diffusion-weighted imaging (DWI) was investigated to assess its utility in differentiating benign versus malignant lesions and has been shown to improve the accuracy of conventional MR [3,4]. The utility of DWI is based on the higher more concentrated cellular environment of a neoplasm resulting in increased restricted diffusion compared to benign lesions or normal breast tissue. Now interest has turned to diffusion tensor imaging (DTI), a more robust form of diffusion imaging, which is based on applying diffusion in multiple directions, which is sensitive to microstructural elements in addition to cellular density.

Theoretically, the diffusion of water molecules in the mammary tissue is directional and well defined by the microarchitecture composed of ductal/glandular trees [5]. Malignant lesions would alter this architecture by blocking and/or disrupting the ductal system. DTI-derived measurements in the breast have been shown to be reproducible [6], and there is evidence supporting its ability to help discriminate between malignant and benign lesions [7–9].

In order for DTI to become clinically useful and gain favor as an adjunct to convention breast MR, DTI in the normal breast must first be fully understood. This requires the standardization of DTI parameters and assessing the normative range as well as improved understanding of factors that influence these values. Few publications have specifically focused on characterizing normal breast tissue [10,11], and to our knowledge, no group has evaluated the effects of fibroglandular tissue (FGT) composition and background parenchymal enhancement (BPE) on DTI measurements. Our goal was to measure DTI parameters at 3 T in normal breast tissue and to assess the influences of FGT composition and BPE.

2. Materials and methods

2.1. Subjects

This Health Insurance Portability and Accountability Act–compliant study involved 27 randomly chosen patients undergoing screening

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or preoperative breast MR during the period from October to December 2013. Informed consent was waived and institutional review board waiver was obtained due to the retrospective nature of the study.

DTI was performed in addition to the standard clinical protocol prior to the contrast injection. Of the 27 patients, 21 patients were included in the cohort and a total of 35 breasts were included in the final analysis. A patient was excluded if she was on neoadjuvant chemotherapy ($n=2$), if the technical quality of the study was poor ($n=2$), or due to prior mammoplasty or augmentation ($n=2$). Of the 21 individuals included in the study, a breast was excluded ($n=7$ of 42 breasts) if it had undergone prior lumpectomy or mastectomy or contained an ipsilateral breast carcinoma. If a breast had a previous benign excision or biopsy, it was included with the region of interest (ROI) drawn at least 2 cm away from the site of surgery/biopsy. The mean age±standard deviation (S.D.) of the subjects was 50±10 years.

2.2. MR image acquisition

DTI was performed on a 3.0-T system (Discovery MR750; GE Healthcare, Waukesha, WI) using the body coil as a transmitter and a dedicated 16-channel phased-array receiver breast coil (Sentinelle Vanguard; Sentinelle Medical, Toronto, ON, Canada). The standard breast MR imaging protocol included a T2-weighted fast spin-echo sequence, a T1-weighted nonfat-suppressed sequence, and a T1-weighted fat-suppressed dynamic contrast-enhanced sequence. Importantly, the DTI sequence was performed prior to the standard protocol as it has been shown that contrast administration alters apparent diffusion coefficient (ADC) values [4].

DTI was performed using a diffusion-weighted dual spin-echo echo-planar imaging sequence and with the following parameters: slice thickness of 4 mm, gap of 0, TR/TE of 9000 s/80–120 ms with three averages, matrix of 128×128, and field of view of 28–34 cm.

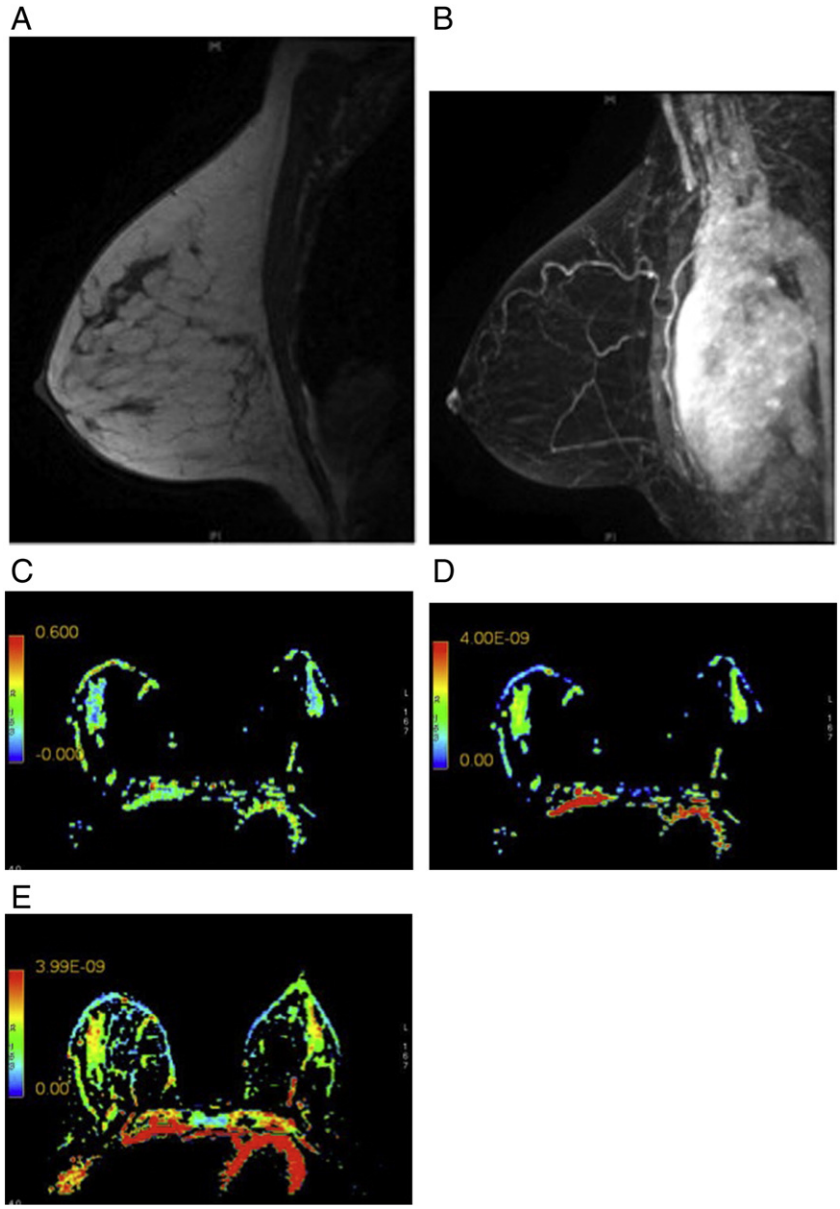

Fig. 1. A 41-year-old female with high-risk assessment presents for screening breast MR imaging. (A) Sagittal T1-weighted nonfat-suppressed MR image shows a normal left breast with scattered FGT. (B) Sagittal T1-weighted fat-suppressed postcontrast maximum intensity projection MR imaging shows a normal left breast with minimal BPE. (C) Axial FA color map. (D) Axial ADC color map, color scale in squared meters per second (m^2/s). (E) Axial λ_1 color map, color scale in squared meters per second (m^2/s).