Quantitative Measures of Breast Density and Tissue Patterns using MRI

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Introduction: Breast density measured on mammography is a very important marker of breast cancer risk [1,2]. Women with high breast density are 4 to 6 times more at risk than women with fattier breasts. Mammography is the current approved modality for measuring breast density, however it does not perform well in populations with dense breasts. In addition, mammography is a 2D projection of the breast, and it lacks the ability to detect subtle early changes occurring in breast tissue. Recent studies have shown the importance of quantifying breast density for assessing breast cancer risk and the need for better clinical measures of breast density [3]. Specifically, there is a strong need to provide quantitative techniques that could assess breast density in young women (with higher breast density) and in high-risk populations, in order for their clinicians to assess their risk appropriately, and potentially propose intervention or preventative methods. Breast MR images provide very high-soft-tissue contrast that allows the quantification of tridimensional structural information of breast tissue composition, such as breast tissue and fat volumes, related to breast density. MRI has been shown to differentiate fat from fibroglandular tissue with high precision, especially in the case of women with very dense breasts [4]. Recent studies have confirmed the strong correlation between mammographic density and MR breast density [5,6]. Figure 1 presents non-contrast MRI data of 4 normal volunteers presenting different breast tissue aspects (or "breast tissue patterns") due to fat involvement or marbling: dense tissue (bright intensities) with limited fat involvement (dark intensities) in (A), dense tissue patterns with more fat involvement in (B), fatty breast with dense region in (C) and fatty breast with little tissue in (D). These MRI data suggest that women who may have similar mammographic breast densities (A and B: high; C and D: low) still present very different MR breast tissue patterns. Identification of new measures detecting these differences in women may be useful to develop new strategies of breast cancer risk assessment. The goal of this project is to provide new quantitative measures of MR breast tissue content and tissue patterns that may have applicability to risk assessment.

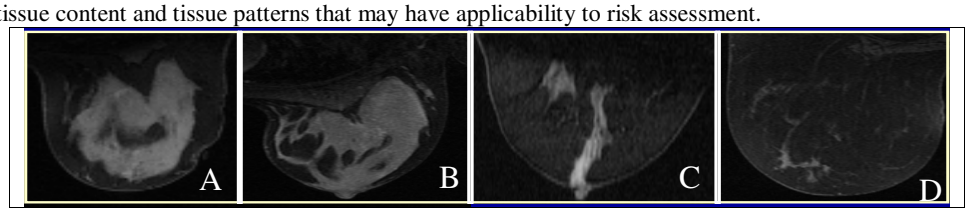

Fig 1. Non-contrast T1-weighted MRI image of 4 normal volunteers.with various tissue patterns; A,B: high breast mammographic densities; C,D: low mammographic densities.

Materials and Methods: In this study we developed MRI quantitative measures to help quantify measures of (1) MR breast density and (2) MR breast tissue pattern indexes. Written informed consent was obtained from 50 normal female volunteers following a protocol approved by the Committee on Human Research at our institution. The subjects were between 24 and 59 years (mean 41). All volunteers underwent a non-contrast bilateral breast MRI performed on a 1.5T Signa system (General Electric Medical Systems, Milwaukee, WI) using a bilateral phased array breast coil. We acquired a non-contrast high-resolution fat suppressed T1-weighted 3D fast gradient echo sequence (3DFGRE) (TR=8.4ms, TE=4.2ms, NEX=2, 256x256matrix, FOV 20cm, Slice thickness 2mm, no gap). T1-weighted images are shown in figure 1. A 3D semi-automated technique based on fuzzy C-means [6] was applied to MRI data of each subject to extract (1) MR breast density (defined as the ratio of breast tissue volume, over the complete volume of the breast) and (2) MR tissue pattern index which estimates edges (due to fat involvement) in breast tissue and is recorded as a continuous value for each subject. By analogy with the BIRADS classification of mammographic densities, we classified all subjects into 4 groups of MR breast densities (1= fatty (<10%), 2=some density (<10-35%), 3=medium dense 35%-50%, 4=high density >50%).

Results: Figure 2 shows the variability of MR tissue pattern indexes (vertical axis) within the 4 MR breast density groups (horizontal axis), and presents indexes (arrows) for volunteers A, B, C, and D. Women with high mammographic breast densities (A and B) presented high MR breast densities but significant different MR tissue patterns (B has more fat involvement than A, creating a different MR tissue pattern index). Similarly, figure 2 shows that women with very fatty breasts (C and D) both present low MR breast densities (<10%) however display very different MR breast tissue pattern indexes (C presenting more compact tissue regions than D). This MR tissue pattern index shows higher variability in the fatty category than in the dense category and may therefore provide additional information complementary to MR breast density alone.

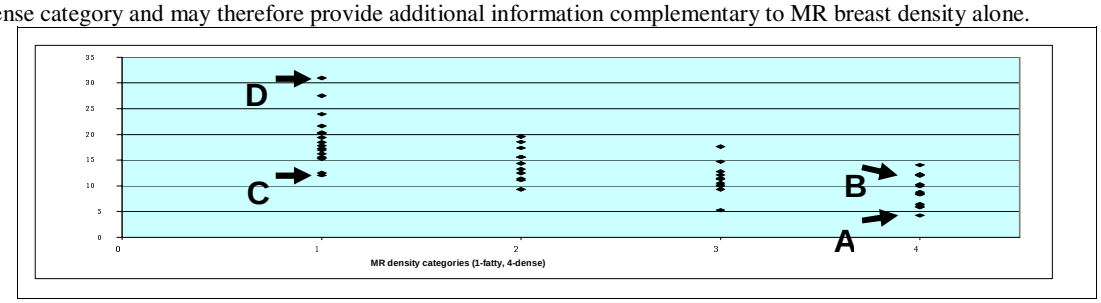

Fig. 2: Evaluation of MR tissue pattern index (vertical axis) in all subjects, classified into 4 groups of MR breast densities (1=fatty, 2=some density, 3=medium dense, 4=very dense). Women with identical MR breast densities (A and B; C and D) present very different MR breast tissue pattern indexes.

Discussion: In this study we defined a new quantitative MRI measure to quantify MR tissue patterns, or fat involvement in breast tissue. We showed that women with very similar mammographic breast densities may exhibit very different MR tissue pattern indexes. This MR index may be complementary to breast density measures and may have some applicability to help improve breast cancer risk assessment strategies. We are studying this index on a larger population of women who had both a mammogram and an MRI, to verify our findings.

References:[1]Boyd NF et al.. Cancer Epidemiol Biomarkers Prev; 1998, 7:1133-1144; [2] Byrne C. J Natl Cancer Inst; 1997 89:531-533; [3] Boyd, Kerlikowske NEJM Jan. 2007; [4] Graham SJ et al., British Journal of Cancer, 1996, 73(2) pp 162-8; [5]Lee NA et al. American Journal of Roentgenology, 1997,168(2): 501-6; [6] Klifa C et al. IEEE Engineering in Medicine and Biology; 2004, 3:1667-1670.