MRI of the breast: quantification of breast density and background enhancement in healthy volunteers

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Background:

Breast density reflects the proportion of epithelial and stromal tissue in the breast as opposed to non-dense fatty tissue. Quantification of breast density is important for two reasons. First, it is used to indicate the relative sensitivity of the mammographic examination for detection of breast cancer, which is lower in patients with dense breasts. Second, there is an association between increased mammographic breast density and increased breast cancer risk. To date, MRI of the breast is increasingly used for imaging and staging of breast cancer patients. It has been suggested that MRI breast density and more important the amount of background enhancement of the fibroglandular tissue after contrast administration, may influence the sensitivity of the breast MRI examination, since severe background enhancement, may obscure small enhancing cancers. To date, the relationship between the assessment and quantification of mammographic density and density on breast MRI has only been investigated in 1 preliminary report. Furthermore, the relation between MRI breast density and amount of background enhancement is unknown.

Purpose:

To compare the quantitative assessment of mammographic breast density and to correlate it with quantitative assessment of MRI breast density (volume fibroglandular tissue / total breast volume). In addition, a semi-automated method developed to differentiate fibroglandular tissue from fat on MRI (3D volume fibroglandular tissue / 3D total breast volume) is used to assess MRI breast density. Finally, the amount of background enhancement on breast MRI that is related to MRI breast density.

Method:

37 Mammography films and Breast MRI scans of 36 healthy female volunteers (1 underwent bilateral breast MRI) were reviewed and scored independently by two radiologists for breast density according to the new BI-RADS (Breast Imaging Reporting and Data System) criteria where breast density is assessed and divided into quartiles: with category 1 indicating breast tissue less than 25% glandular (fatty); category 2 breast tissue 25%-50% glandular (scattered fibroglandular); category 3 breast tissue 51%-75% glandular (heterogeneously dense); and category 4 breast tissue more than 75% glandular (dense). MRI breast density was scored on the non-contrast enhanced T1-weighted (T1-FSE) series, whereas background enhancement was quantified on first contrast-enhanced T1-weighted fat-suppressed series, and scored according to similar categories. The pattern of MRI background was scored as follows: Stippled, Scattered foci, Clustered Foci, Heterogenous and Homogenous. For 3D breast density quantification a semi-automated method to differentiate fibroglandular tissue from fat, and to quantify the total tissue and volume of the breast was used. In this technique a specific graphical user interface allows interactive delineation of the total breast volume and automatically segments breast tissue from fat within the entire breast volume.

Results:

The baseline characteristics of the 36 patients (ranging 31-57 years of age) included: 16 premenopausal and 17 menopausal women (3 status unknown). The average BMI of our cohort is 22, only two women were overweighted (BMI >25). Using the standard Quantitative BI-RADS density score, a majority of the cases 29/37 (>78%) have either heterogeneously dense or dense breasts on mammography. Based on 3D MRI scoring this percentage was 24/37 (65%). Although there was a difference between mammographic breast density (2D) and MRI breast density as scored by radiologist, no statistical significance was reached between both methods ($P<0.21$) However, based on the semi-automatic method for MRI breast density quantification, significantly less cases were classified as heterogeneously dense or dense: 8/37 (22%), $p<0.05$ (See results table 1). No relation between the amount of background enhancement and breast density was found. The majority 28/37 (76%) of our cohort had minimal (<25%) MRI background enhancement. The most common pattern of background enhancement detected was "scattered foci".

Conclusion:

Although quantitative BI-RADS breast density score is traditionally used as the gold standard in assessing breast density on mammography, it relies on 2D visualization, and because its dependence on the radiologist's visual assessment, is prone to subjectivity. MRI, which is increasingly used as part of the management of breast disease may be a better tool for assessment of breast density, because the breast is imaged in 3D. Our study results show that mammographic BI-RADS breast density score is likely to over-estimate the amount of fibroglandular tissue compared to whole breast volume. This is because the 2D mammographic image combines superimposed areas of fibroglandular tissue and intermittent fat together, hence the density appearance is higher than the "actual density". Based on our study results we hypothesized that 3D MRI density quantification is a more reliable method for breast density assessment. To allow reproducible 3D MRI breast density measurements we developed a semi-automatic quantification method. Our study also shows that there was no relation between breast density and amount of background enhancement in healthy volunteers.

Imaging modality	<25 % fatty	25-50% scattered fibroglandular	51-75% heterogeneously dense	>75% dense
MMG Density 2D	2	6	10	19
MRI Density 3D Radiologist	3	10	15	9
MRI Density 3D semi-automatic	19	10	7	1
MRI Background enhancement	28	3	6	0

Table 1: results of breast quantification according to different techniques

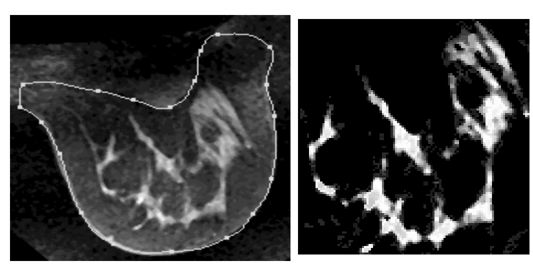

Figure 1. Example of breast density scoring: density scored on mammography as 25-50% (scattered fibroglandular), MRI density 3I 25-50% scattered fibroglandular and MRI density after 3D segmentation: volume of fibroglandular tissue / volume whole breast = 0.18 (<25% fatty)