Breast imaging: is the sonographic descriptor of orientation valid for MR imaging?

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Purpose

The Breast Imaging Reporting and Data System (BI-RADS) helps to standardize the interpretation and reporting of imaging findings, improving communication between radiologists, clinicians, surgeons and pathologists. Unlike the descriptors of shape and margins commonly used on mammography (MMG), ultrasound (US) and magnetic resonance (MR), the orientation of a lesion is considered relevant only for ultrasound.

The definition of orientation under US has significant positive predictive value (PPV) for malignancy and has been evaluated by several authors.

An alternative explanation for the difference between orientation of longest axis of benign and malignant lesions relies on the fact that fibroadenomas (and other benign lesions) are more mobile and prone to compression imposed by the transducer during the examination, when patients lie in supine position. Another explanation suggests that growth of benign lesions respects the anatomic planes of breast, following the radial orientation of ducts and suspensory ligaments.

Classically, the orientation of nodules on US is defined according to lesion’s relationship to the skin, in parallel and non-parallel. The identification of Cooper’s ligaments on US images is usually straightforward. Also on MR images these ligaments are also easy to visualize. Cooper’s ligaments are usually identified in a relatively constant orientation for the majority of patients.

Additionally, some recent studies have shown limitations in the ability of the BI-RADS descriptors to differentiate between benign and malignant lesions, which emphasizes the importance of searching new parameters that could aid in lesion’s characterization.

Therefore, we conducted this study to evaluate if lesion orientation by MR imaging may be an useful criterion for distinguishing between benign and malignant lesions and if MR orientation correlates with sonographic one.
Methods and Materials

ETHICS

This retrospective single institution study was approved by our institution's Ethics Committee in Research.

SUBJECTS

We evaluated 243 consecutive breast MR exams that were performed at our institution from February 2008 to October 2010, following the inclusion criteria described on Table 1.

We excluded patients with previous biopsy and/or undergoing any type of treatment (chemotherapy, radiotherapy). After exclusions, we selected 64 patients with a total of 71 lesions.

MR PROTOCOL

MR examinations were performed on 1.5 T scanners, 37 exams were conducted in a dedicated breast surface coil with 4 channels and 27 exams in a coil with 8 channels, always in the prone position.

The first sequences performed were pre-contrast T1-weighted and T2-weighted, with and without fat suppression, in the axial, sagittal and coronal planes, followed by dynamic acquisitions after intravenous (IV) injection of a paramagnetic contrast agent, gadopentate dimeglumine (0.1 mmol / L / kg) and 20 ml of saline solution flush. We used a slice thickness of 4.0 mm for 2D sequences and 1.0 mm for 3D sequences.

ULTRASOUND PROTOCOL

Ultrasonography was performed by medical staff at our institution, all with at least 5 years of experience in breast US. We used a high frequency linear probe, 7.0 to 12 Mhz.

IMAGE INTERPRETATION
US and MR images were independently evaluated by two observers, with 10 and 4 years of experience in breast imaging, both unaware of patient clinical history and the histopathological results. Discordant results were re-evaluated together to reach a consensus.

All lesions were also measured on axes anteroposterior (AP) cranio-caudal (CC) and transverse (T) axes.

The assessment of MR orientation was performed by confronting the longest axis of the lesion in relation to Cooper’s ligaments.

Cooper’s ligaments were best visualized on T2-w, non-fat suppressed images and T1-w post-contrast images as delicate lines extending from the pectoral muscles to the subcutaneous tissue and skin, traversed by breast parenchyma (figure 1).

Therefore, for MR, lesions were classified as non-parallel when the longest axis was perpendicular to Cooper’s ligaments and parallel when the longest axis was parallel to the ligaments, regardless of traversing the ligaments or not (figures 2 and 3). Round lesions, with similar measurements on the three axes, were classified as non-parallel, analogous to criteria used for US.

The orientations of the lesions on ultrasound images were determined according to their relation to the skin planes and were classified as parallel when the CC or T axes were longer than the AP axis and non-parallel when the AP axis was the longest axis.

**DIAGNOSTIC CONFIRMATION**

All patients underwent needle biopsy, core biopsy and/or excisional biopsy. A pathologist dedicated to breast disease, with 14-year experience in this field, analyzed the tissue samples.

**STATISTICAL ANALYSIS**

Statistical analysis included the calculation of the inter-observer agreement using the Kappa test for US and MR, analysis of diagnostic accuracy for the descriptor of orientation on US and MR imaging, and, additionally, we evaluated the association between sonographic and MR orientation for all lesions. The limit for significance was set at 0.05.
Images for this section:

**Table 1**: Inclusion criteria.

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Fig. 1: Axial T1-weighted MR images. Cooper´s ligaments can be seen in fatty breasts, ACR composition 1 (arrows in A), but also in dense breasts, ACR composition 3 (arrows in B).

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Fig. 2: Axial (A) and sagittal (B) T1-weighted images of a mass-like lesion parallel to the breast suspensory ligaments (fibroadenoma). In (C) an irregular lesion (invasive ductal carcinoma) can be seen on sagittal T1-weighted image with the longest axis non-parallel to Cooper's ligaments (arrows).

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**Fig. 3:** MRI T1-weighted images on axial (A) and sagittal (B) views showing an ovoid and regular lesion (fibrocystic changes) with the longest axis parallel to the breast suspensory ligaments. Axial (C) and sagittal (D) T1-weighted images of the same patient, contralateral breast demonstrate a small irregular mass non-parallel to and crossing the Cooper’s ligaments (invasive ductal carcinoma).

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Results

Sixty-four patients with a shared total of 71 distinct mass lesions were enrolled in this study. The mean age was 49.6 years, ranging from 24 to 70 years.

Thirty lesions were malignant (42.2%) and 41 benign (60.7%). The histopathologic diagnosis are detailed in table 2.

There was no significant difference between the MR and the sonography measurement of the lesions.

The US and MR imaging classification interobserver agreement evaluated by kappa test were 0.81 (95% CI - 0.58 - 1.0) and 0.70 (0.47 - 0.93), respectively. We also evaluated the concordance between the final classifications obtained for US and MR imaging, and the kappa test value was 0.91 (0.68 - 1.0).

Of the 71 lesions evaluated, 44 were parallel and 27 were non-parallel by MR imaging. For the 44 parallel lesions seen on MR imaging, 33 were benign and 11 were malignant. Among the 27 non-parallel lesions, 19 were malignant and 8 were benign (table 3).

For US images, of the 45 parallel lesions, 34 were benign and 11 were malignant, while for the 26 non-parallel lesions, 19 were malignant and 7 were benign (table 4).

There was agreement between the two methods for all except three lesions, one benign and non-parallel on MR imaging and two malignant, one parallel and one non-parallel on MR. The correlation between the orientation on ultrasound and MR imaging is shown in table 5 and illustrated in figures 4, 5 and 6.

We found 11 malignant lesions (36.7% of all malignancies) that showed parallel orientation on both US and MR imaging. All of these lesions had descriptors of shape and margins that suggested malignancy.

Seven benign lesions by US and 8 by MR imaging had non-parallel orientation and were considered false positive for both methods, the majority of which were fibroadenomas.
The PPV for malignancy for non-parallel orientation was 70.4% for MR and 73.1% for US. The US and MR imaging diagnostic performance using orientation as the only criterion are shown in table 6.
Table 2: Histopathologic diagnosis.

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Table 3: Orientation on MR imaging according to Cooper's ligaments versus the final diagnosis.

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<th>MR Parallel</th>
<th>MR Non-Parallel</th>
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<td>8</td>
<td>41</td>
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<tr>
<td>Malignant</td>
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<td>19</td>
<td>30</td>
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<tr>
<td>Total</td>
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<td>27</td>
<td>71</td>
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Table 4: Orientation on ultrasound according to Cooper’s ligaments versus the final diagnosis.

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<td>41</td>
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<tr>
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<td>19</td>
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<td>Total</td>
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Table 5: Correlation between the lesion orientation on ultrasound and MR imaging using Cooper’s ligaments as reference.

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**Fig. 4:** Benign lesion (fibroadenoma). Ultrasound image (A) showing an ovoid and circumscribed lesion (asterisk) parallel to the skin. MR sagittal T1-weighted image (B) demonstrates the same lesion (asterisk) parallel to Cooper’s ligaments (arrows).

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**Fig. 5:** Invasive ductal adenocarcinoma. An ovoid, irregular and non-parallel lesion seen on ultrasound (A) has the same orientation on axial T1-weighted image (B), where the lesion (asterisk) can be seen crossing a Cooper’s ligament (arrow).

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Fig. 6: Invasive ductal Carcinoma. Ultrasound image (A) showing an irregular lesion with the longest axis parallel to the skin. On MR sagittal T1-weighted image (B) of the same patient, the lesion (asterisk) is non-parallel to and crossing the Cooper’s ligaments (arrows), illustrating a case of discordance between the two methods.

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Table 6: Diagnostic performance of US and MR imaging using only orientation as a diagnostic criterion for malignancy.

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Conclusion

1. The non-parallel orientation on MR showed a high PPV (70.4%) and specificity (80.5%) for malignant lesions and may be considered a suspicious finding for mass lesions.

2. US and MR orientations also had similar sensitivity, specificity, accuracy and NPV, which favors our hypothesis that this descriptor could be used on MR imaging, always considering that analysis of several parameters increases the diagnostic accuracy when compared to evaluation by a single criterion.
References


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