AJR WOMEN'S IMAGING

BI-RADS–MRI: A Primer

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OBJECTIVE. Variations in breast MRI techniques and descriptions of morphologic findings led to the development of a breast MRI lexicon. This lexicon, the American College of Radiology's BI-RADS–MRI, includes terminology for describing lesion architecture and enhancement characteristics. We show the use of these descriptors on breast MR images obtained at our institution.

CONCLUSION. BI-RADS–MRI is a common language with which to report MRI findings of studies from different institutions.

Keywords: BI-RADS, breast cancer, dynamic MRI

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Dynamic contrast-enhanced MRI of the breast is becoming increasingly useful in the detection, diagnosis, and management of breast cancer. To overcome difficulties arising from lack of standardization among radiologists in describing lesions and communicating results to referring physicians, the American College of Radiology in 2003 developed the BI-RADS–MRI lexicon, published as a part of the American College of Radiology's *Breast Imaging Reporting and Data System Atlas* [1].

The aim of this pictorial essay is to provide practicing radiologists with illustrations of the descriptors defined in the BI-RADS–MRI lexicon. For this purpose, we reviewed breast MR images obtained at a large academic institution. Technical issues and technical variations were not addressed.

General Principles

For reliable assessment with breast MRI, it is crucial to obtain images with high temporal and high spatial resolution. In addition, data on morphologic lesions should be accompanied by kinetic time–intensity information. Lesion information should include lesion location, described as the clock-face location of the lesion within the breast and the distance from the nipple.

Morphologic Assessment of Enhancement

Enhancing lesions are divided into three main categories: focus or foci, masses, and nonmasslike enhancements.

Focus and Foci

Focus and foci are enhancements measuring less than 5 mm that cannot be otherwise specified (Fig. 1). Focus or foci are frequently stable on follow-up images and may result from hormonal changes.

Masses

A mass is a 3D lesion that occupies a space within the breast. Masses are described in terms of shape, margin, and internal enhancement characteristics.

Shape—A mass can be round, oval, lobulated, or irregular (Fig. 2). Lobulated masses have an undulating contour (Fig. 2C). Irregular masses (Fig. 2D) have an uneven shape that cannot be characterized as round, oval, or lobulated.

Margin—Margins can be described as smooth, irregular, or spiculated (Fig. 3). Spiculated margins frequently are a feature of malignant breast lesions and radial scars [2].

Internal enhancement characteristics—Enhancement patterns of masses have been divided into the following six types:

Homogeneous enhancement is uniform and confluent enhancement throughout the mass (Fig. 4A).

Heterogeneous enhancement is nonuniform enhancement that shows variations within the mass (Fig. 4B).

Rim enhancement is enhancement mainly concentrated at the periphery of the mass. Rim thickness is not well defined. This type of enhancement is most frequently a feature of high-grade invasive ductal cancer [3, 4],

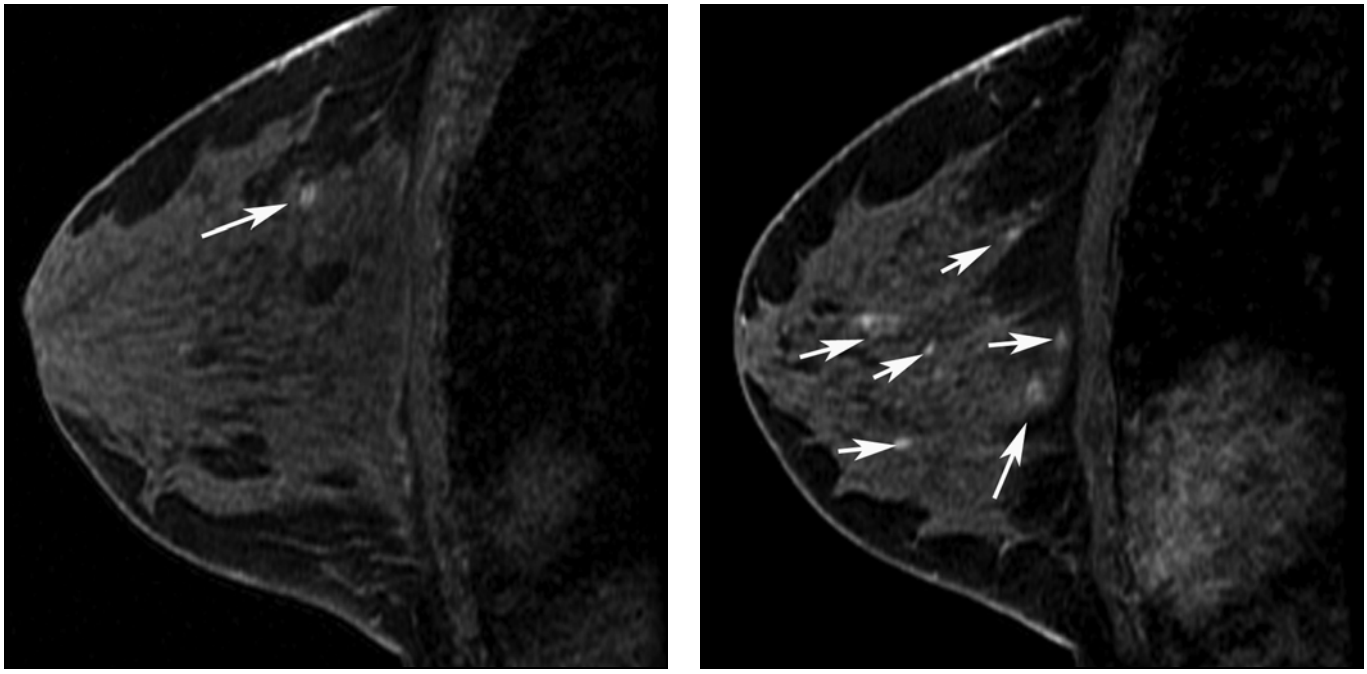


Fig. 1—Focus and foci of enhancement. 49-year-old woman with palpable abnormality in right breast and radiologic findings suggestive of fibrocystic disease.
A, Dynamic contrast-enhanced sagittal 3D fast spoiled gradient-recalled echo image (TR/TE, 7/2; flip angle, 20°; matrix size, 256 × 160; slice thickness, 4 mm; interslice gap, 2 mm; field of view, 20 cm) of left breast with fat suppression shows subcentimeter focus (*arrow*) of delayed enhancement in upper aspect of right breast.
B, Multiple foci of enhancement (*arrows*) throughout right breast. All foci were stable for at least 1.5 years and were considered benign.

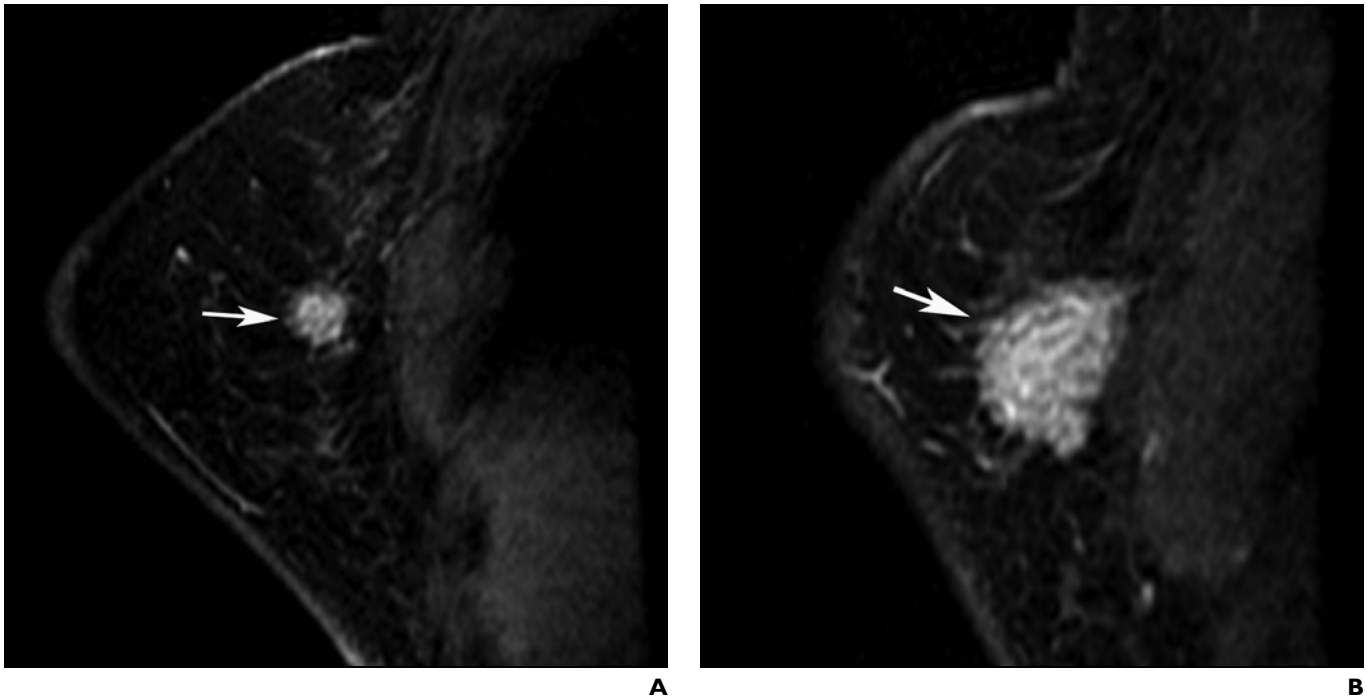


Fig. 2—Mass shape may be defined as round, oval, lobulated, or irregular.
A–D, Maximum slope of increase images obtained in first 2 minutes after contrast injection show malignant masses (*arrows*) with round (**A**), oval (**B**), lobulated (**C**), and irregular (**D**) shapes. Irregular accompanied by abnormal nipple enhancement and retraction (*arrowhead*, **D**) suggest involvement.
(Fig. 2 continues on next page)

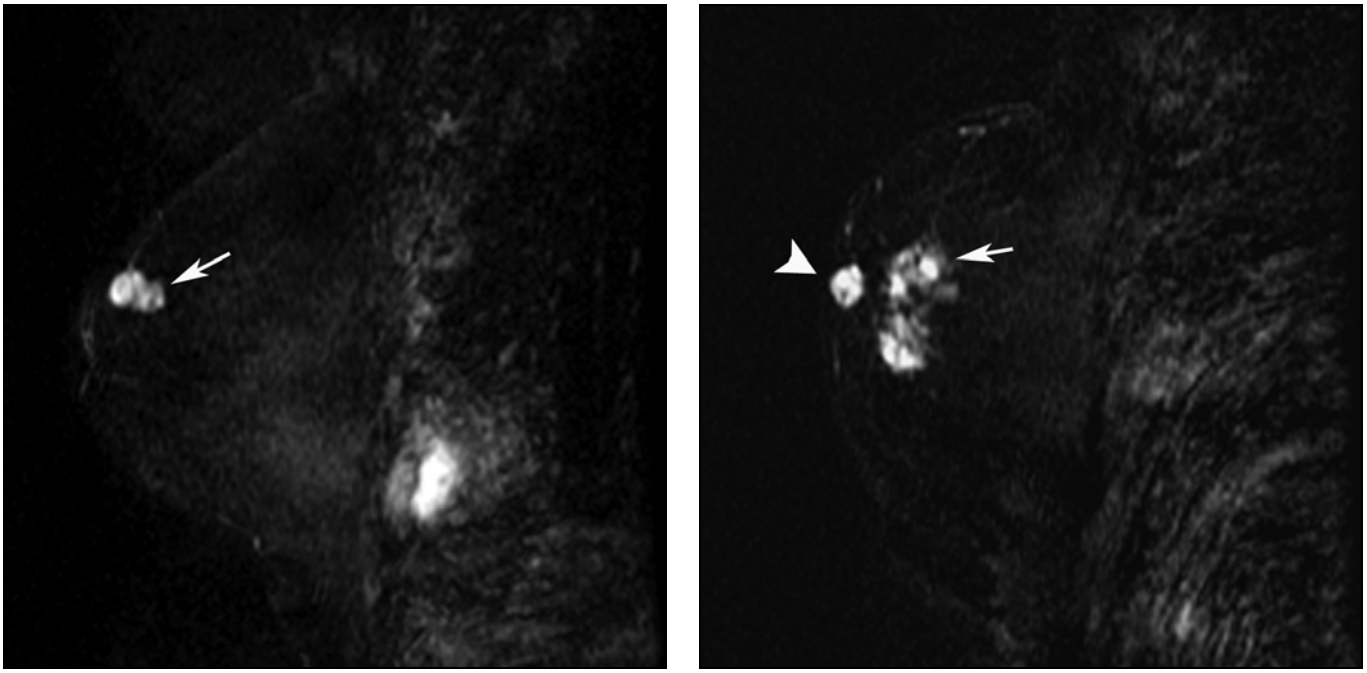


Fig. 2 (continued)—Woman with breast cancer. Mass shape may be defined as round, oval, lobulated, or irregular.
A–D, Maximum slope of increase images obtained in first 2 minutes after contrast injection show malignant masses (*arrows*) with round (**A**), oval (**B**), lobulated (**C**), and irregular (**D**) shapes. Irregular accompanied by abnormal nipple enhancement and retraction (*arrowhead*, **D**) suggest involvement.

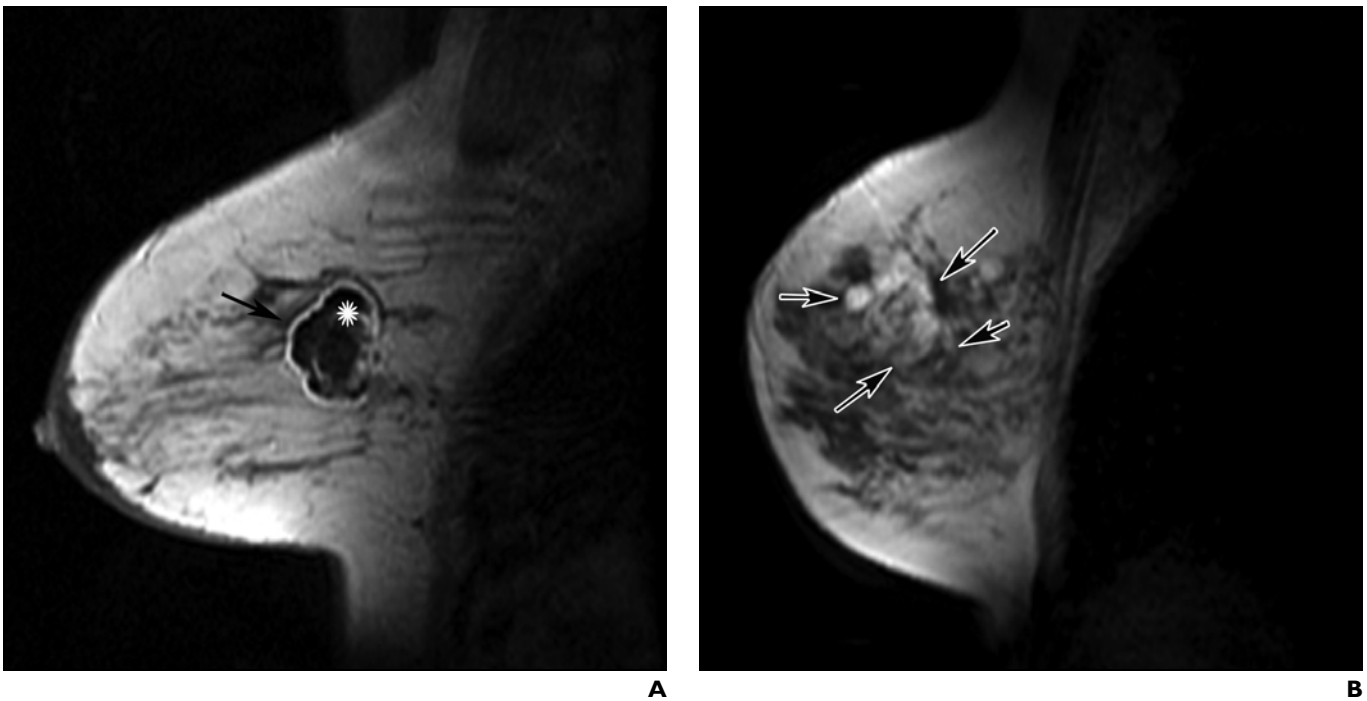
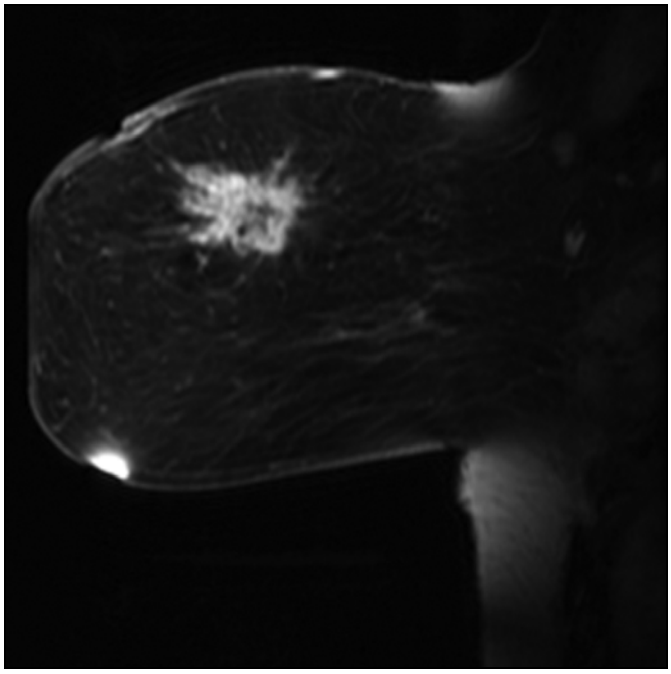


Fig. 3—Mass margins can be defined as smooth, irregular, or spiculated.
A, Sagittal 3D fast spoiled gradient-recalled echo (3D FSPGR) image of woman shows oval mass with early peripheral enhancement and smooth margins (*arrow*) in central aspect of breast. Mass contains central unenhanced area (*asterisk*) representing necrosis.
B, Sagittal 3D FSPGR image shows mass with irregular shape and irregular margins (*arrows*).
(Fig. 3 continues on next page)



C

Fig. 3 (continued)—Mass margins can be defined as smooth, irregular, or spiculated. **C,** Sagittal 3D FSPGR image with fat suppression shows round mass with spiculated margins.

fat necrosis, and cysts with inflammation (Fig. 4C).

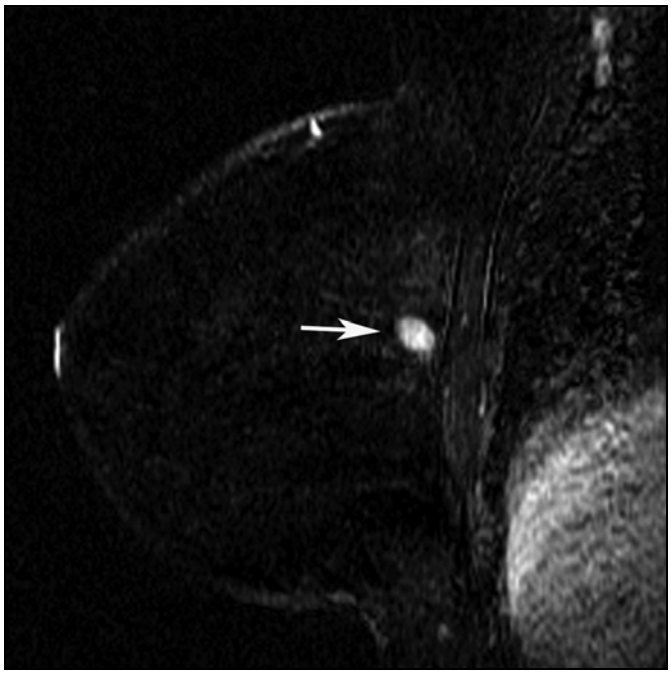
Dark internal septations not enhanced within an enhanced lesion are typical of fibroadenomas, especially when the lesion has smooth or lobulated borders [5] (Fig. 4D).

Enhanced internal septations are usually a feature of malignant lesions (Fig. 4E).

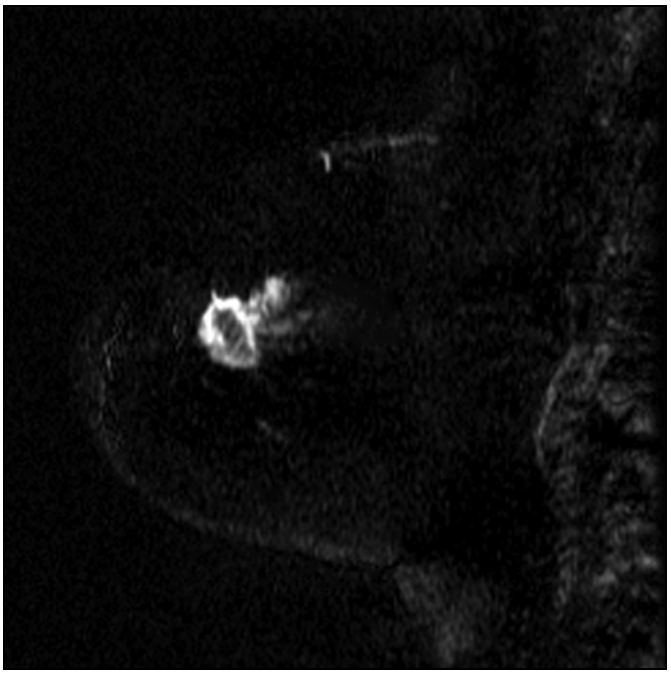
Central enhancement is enhancement of a nidus within a mass that is usually more pronounced than the rest of the enhanced mass. Central enhancement has been associated with high-grade ductal cancer and vascular breast tumors [3] (Figs. 4E and 4F).

Nonmasslike Enhancements

A nonmasslike enhancement is an area of enhancement that does not belong to a 3D mass or have distinct mass characteristics. Features of nonmasslike enhancement are categorized by distribution, internal enhancement pattern, and symmetric or asymmetric en-



A



B

Fig. 4—Internal enhancement characteristics of masses.
A, Homogeneous enhancement in 32-year-old woman with peripheral T-cell lymphoma involving right breast. Sagittal maximum slope of increase image shows oval, homogeneously enhanced mass (*arrow*) with smooth borders in posterior central right aspect of breast representing lymphomatous involvement.
B, Heterogeneous enhancement. Sagittal maximum slope of increase image shows irregular borders and heterogeneous internal enhancement at 12-o'clock position. Histopathologic evaluation revealed invasive ductal cancer.
(Fig. 4 continues on next page)

hancement. Assessment of symmetric or asymmetric enhancement should be reserved for bilateral MRI studies only.

Distribution—A focal area is enhancement occupying less than 25% of the volume of a breast quadrant that has fat or normal glandular tissue between abnormally enhanced components. This type of enhancement usually manifests as clumped, irregular contrast enhancement (Fig. 5A).

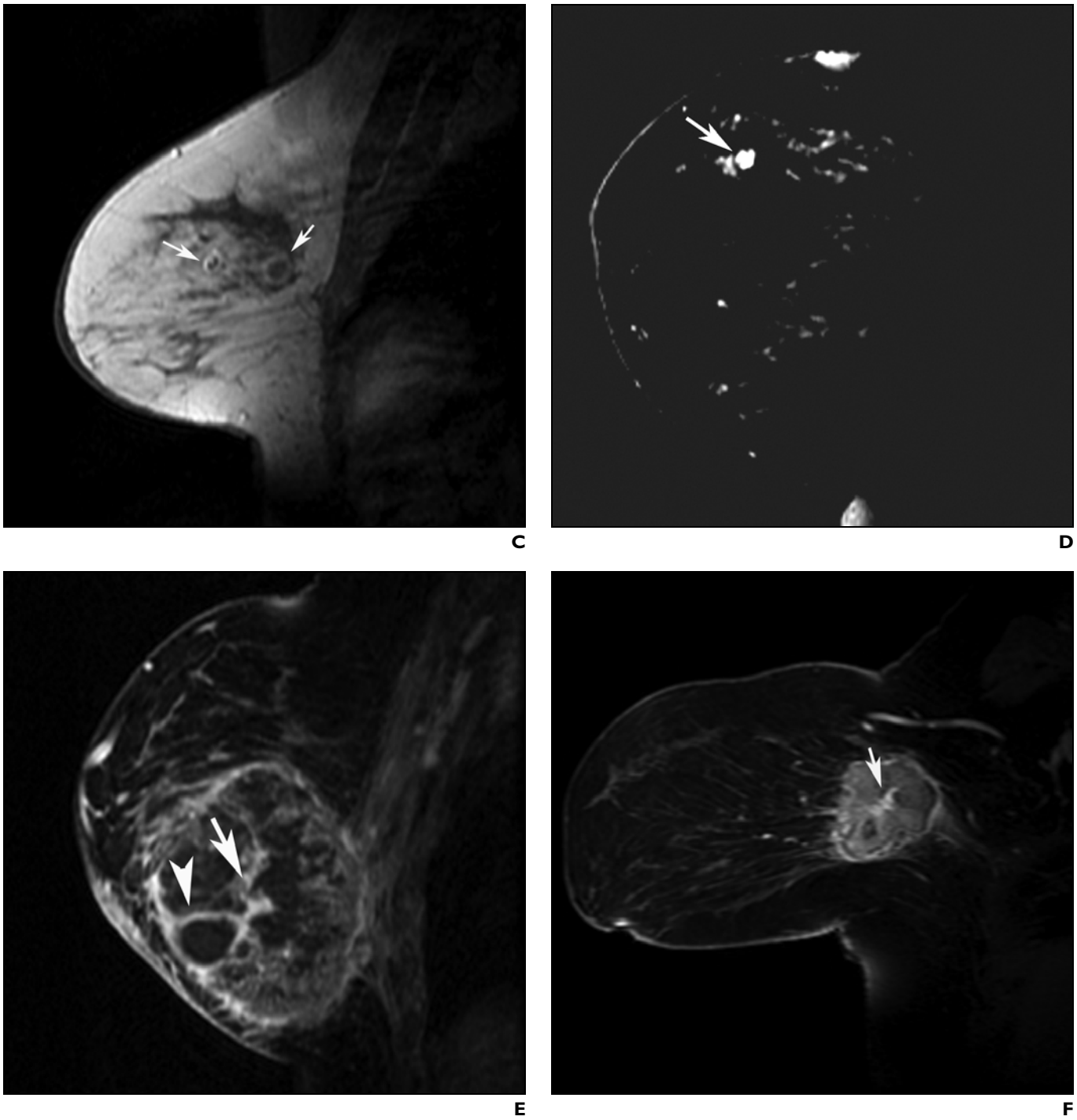


Fig. 4 (continued)—Internal enhancement characteristics of masses.
C, Rim enhancement. Sagittal 3D fast spoiled gradient-recalled echo image shows two smooth, round masses (*arrows*) with rim enhancement in central posterior aspect of breast of patient with multicentric breast cancer.
D, Dark internal septations. Sagittal maximum slope of increase image shows smooth, oval mass (*arrow*) with hypointense central septations suggestive of fibroadenoma.
E and **F,** Central enhanced nidus (*arrows*) and enhanced internal septum (*arrowhead*, **E**). Pathologic assessment of both lesions revealed invasive high-grade ductal carcinoma.

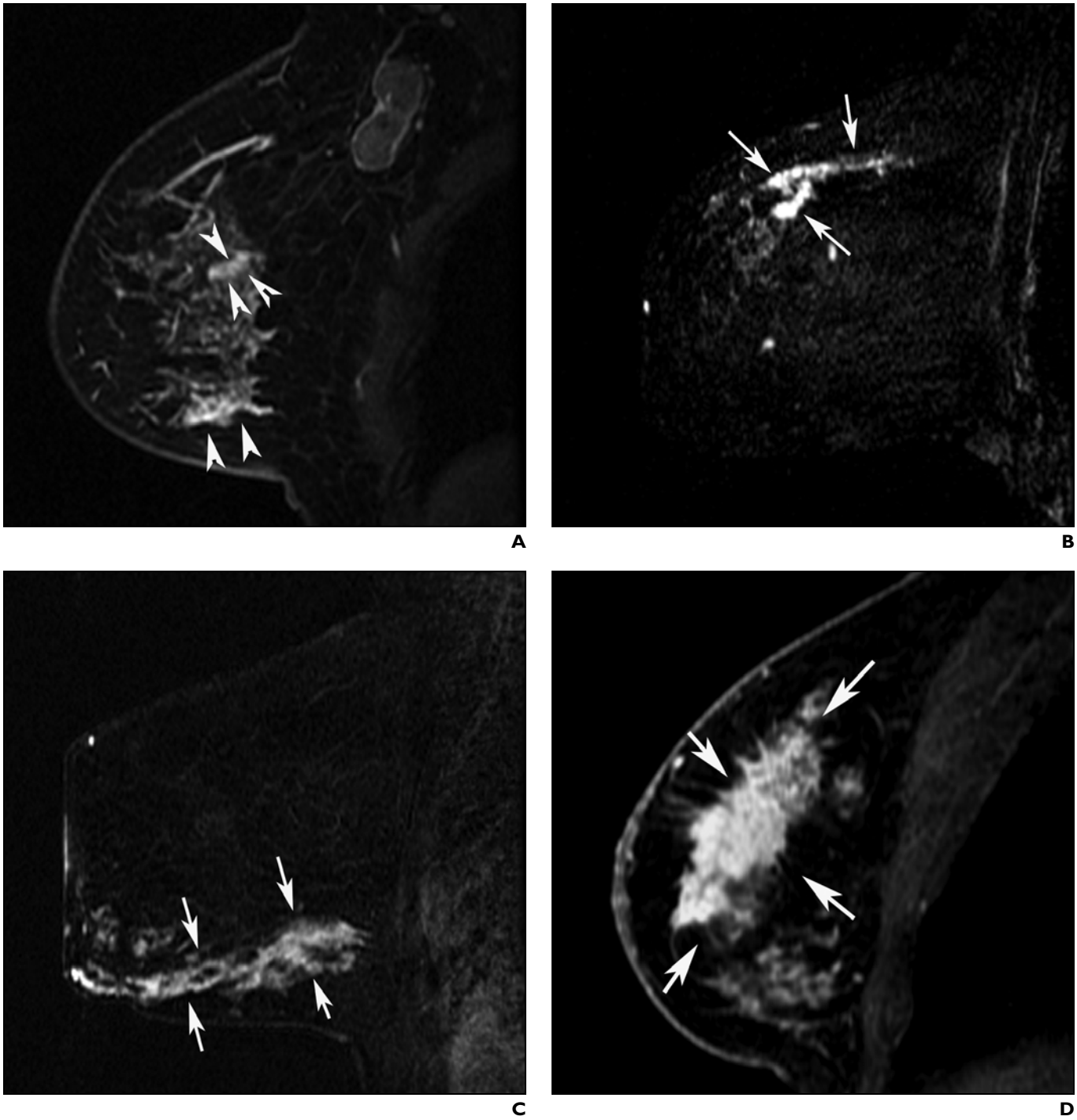


Fig. 5—Nonmasslike enhancements.
A, Woman with focal, clumped, nonmasslike enhancement (*arrowheads*) in upper and lower outer aspects of left breast representing multicentric ductal cancer. Lesions significantly decreased in size after neoadjuvant chemotherapy.
B, Maximum slope of increase image obtained in first 2 minutes after contrast injection shows ductal enhancement (*arrows*) in upper aspect of right breast. Pathologic result was invasive ductal carcinoma.
C, Segmental enhancement (*arrows*) in lower outer aspect of right breast as shown on sagittal early contrast-enhanced subtraction image. Pathologic result was invasive ductal carcinoma with extensive intraductal component.
D, Regional enhancement. Woman with locally advanced breast tumor (*arrows*) in right breast involving upper outer region of breast. Enhancement diminished on subsequent MR images obtained over course of neoadjuvant chemotherapy, demonstrating response to therapy (not shown).

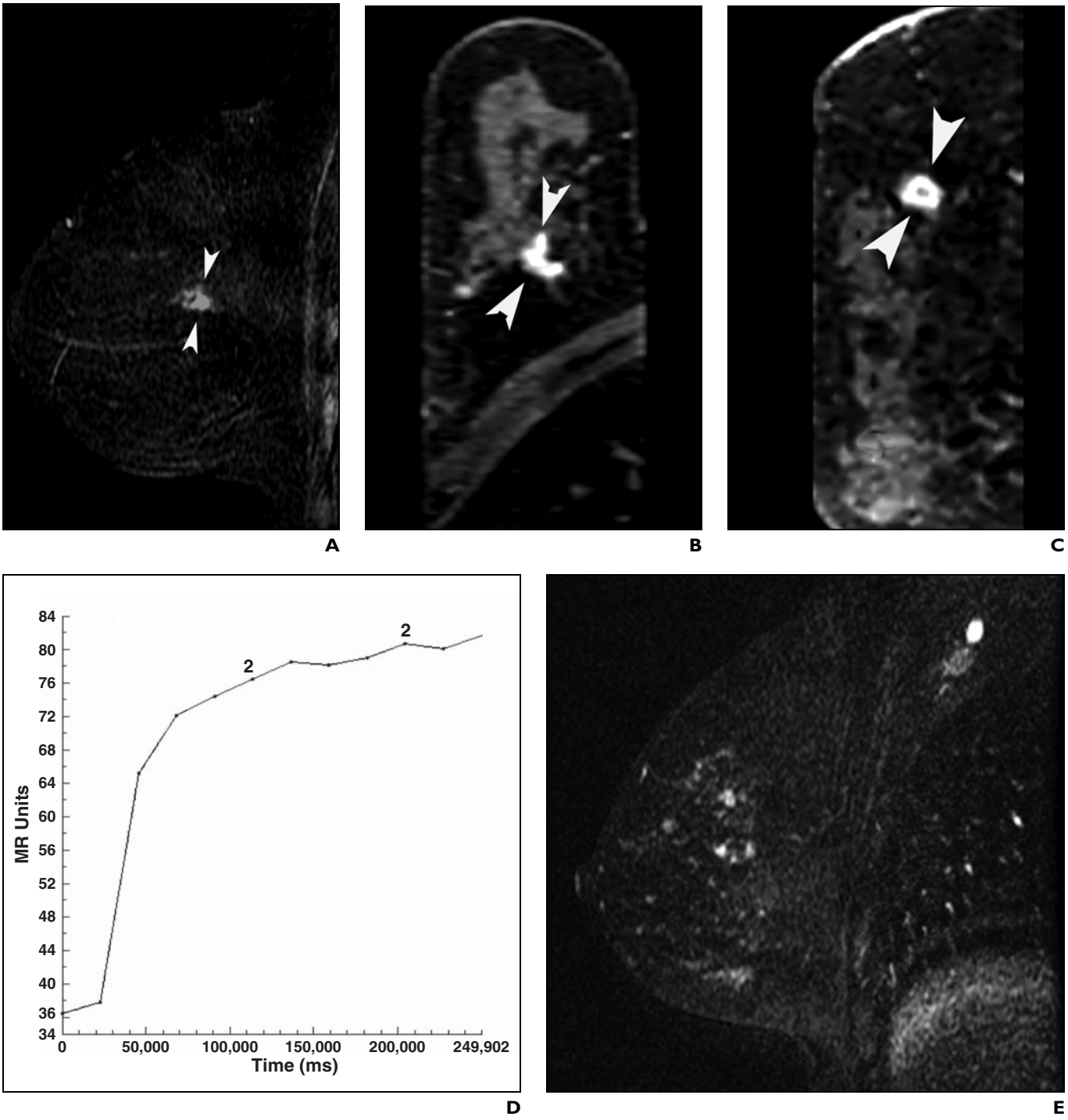


Fig. 6—Internal enhancement characteristics of nonmasslike enhancements.
A–C, Sagittal (**A**) contrast-enhanced dynamic, reconstructed axial (**B**), and coronal (**C**) images show clumped enhancement (*arrowheads*) in upper outer aspect of left breast with right locally advanced breast cancer.
D, Dynamic time–intensity curve shows initial rapid upslope followed by continuous increase in signal intensity. MR-guided biopsy revealed fibrocystic disease.
E, Stippled or punctate enhancement representing hormonal changes in premenopausal woman. Follow-up MR study showed stability of these lesions (not shown).

Linear enhancement is a sheet of enhancement that does not conform to the shape of a ductal system.

Ductal enhancement conforms to the shape of a ductal system, pointing toward the nipple (Fig. 5B).

Segmental enhancement is conical and probably represents one or more ductal systems (Fig. 5C). Ductal and segmental distri-

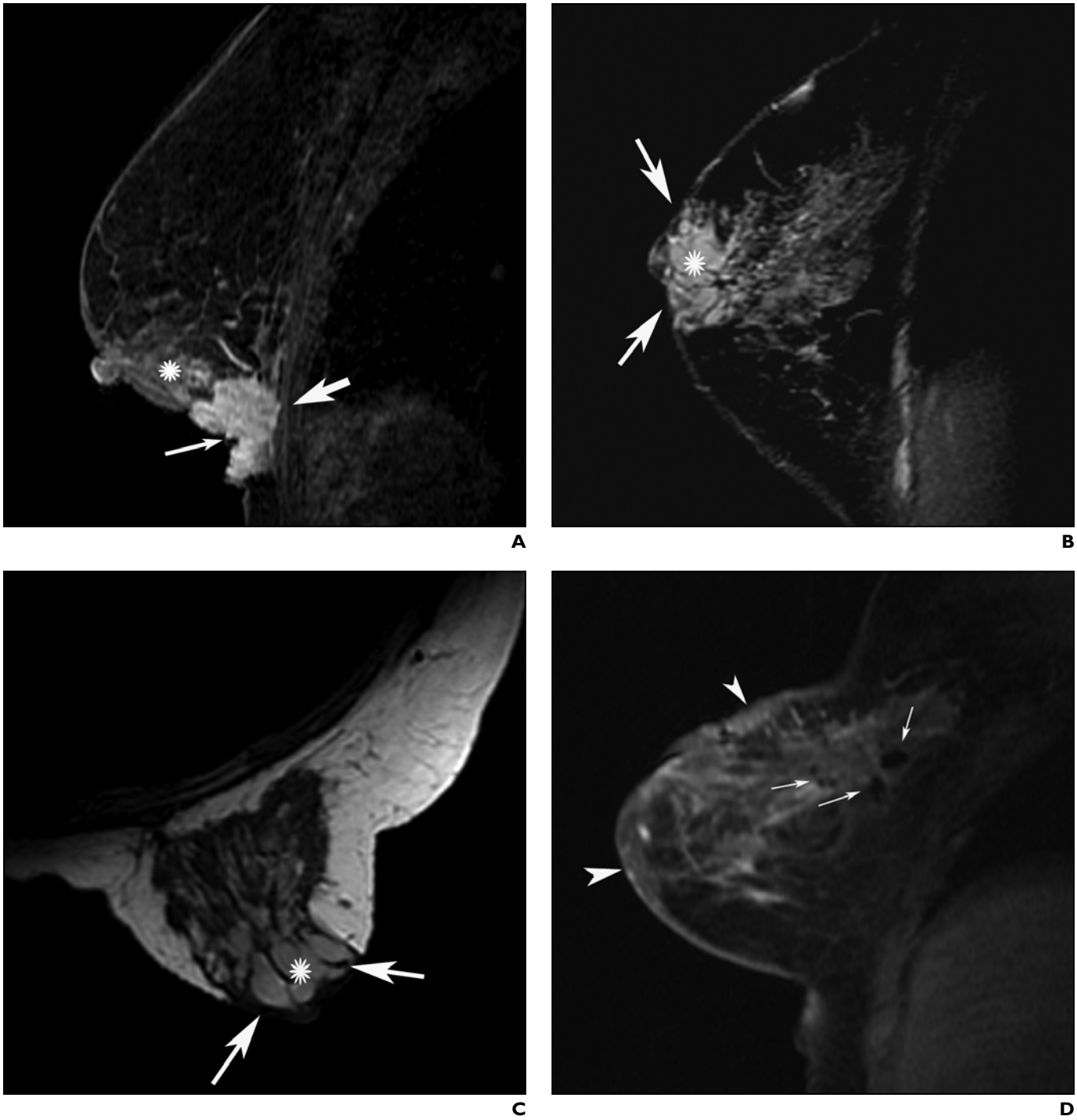


Fig. 7—Associated findings.
A, Pectoralis muscle or chest wall invasion (*thick arrow*), skin involvement (*thin arrow*), and reticular enhancement (*asterisk*) in woman with T4 breast cancer.
B and **C,** Unenhanced high signal intensity in ducts. Sagittal T2 (**B**) and axial T1 (**C**) images show subareolar dilated ducts (*arrows*) with areas of high signal intensity (*asterisks*). These areas represent benign ectatic ducts containing secretion with increased protein content.
D, MR image of right breast after right segmentectomy for invasive ductal cancer shows abnormal signal voids (*arrows*) that denotes surgical clips. Deformity and skin thickening (*arrowheads*) due to surgery and radiation therapy are evident.

bution of enhancement may be associated with in situ ductal cancer or invasive ductal cancer, atypical ductal hyperplasia, papillary neoplasms, or sclerosing adenosis [6].

Regional enhancement is geographic enhancement involving one or more seg-

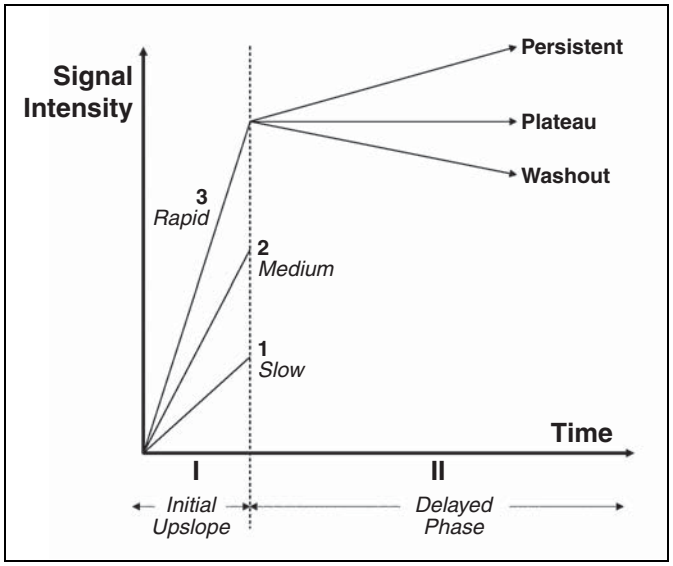


Fig. 8—Kinetic curve assessment. Curve interpretation is composed of two sections: I, Initial upslope of curve can be slow (1), medium (2), or rapid (3). This period is first 2 minutes of dynamic scan or until first change in curve, depending on dynamic parameters used. II, Delayed phase comprises period after first 2 minutes or until curve starts to change. Continued increase in enhancement is persistent pattern; steady leveling in enhancement is plateau pattern; and decrease in signal intensity is washout pattern. Washout pattern and plateau pattern occurring early in dynamic study are more likely to be associated with malignancy, whereas persistent pattern is usually detected with benign lesions, such as fibroadenoma, radial scars, and lesions associated with hormonal changes.

ments of the breast. A specific ductal or segmental configuration cannot be discerned (Fig. 5D).

Multiple regions of enhancement are distributed in several areas of the breast.

Diffuse enhancement is uniform enhancement of the entire parenchyma of the breast, usually associated with benign processes or normal fibroglandular tissue.

Internal enhancement pattern—The internal enhancement patterns are homogeneous, heterogeneous, clumped (Figs. 6A–6D), stippled or punctate (Fig. 6E), and reticular or dendritic. In the reticular or dendritic pattern, the normal fat–glandular tissue interface is lost. This finding is usually associated with inflammatory breast cancer or lymphatic involvement (Fig. 7A).

Associated Findings

Associated findings with or without enhancement should be noted (Fig. 7). These findings include nipple retraction or inversion, skin retraction, skin thickening, skin invasion, pectoralis muscle or chest wall invasion, high signal intensity in ducts on unenhanced images, abnormal signal void, hematoma, edema, lymphadenopathy, and cysts.

Kinetic Curve Assessment

The most suspicious curve pattern derived from the fastest-enhancing part of a lesion is chosen to describe the enhancement curve. The initial enhancement phase—enhancement within the first 2 minutes after contrast injection or until the curve starts to change—is described as slow, medium, or rapid. The delayed phase is described as persistent, plateau, or washout (Fig. 8). Lesions with rapid or medium initial enhancement followed by a delayed phase plateau or washout have a positive predictive value of 77% for malignancy [7].

Conclusion

The American College of Radiology's BI-RADS–MRI lexicon has overcome many issues regarding standardization of lesion descriptions. Part of the lexicon is a reporting system similar to that used in mammography and involves the overall impression the radiologist has derived from these descriptors. Increased use of the American College of Radiology's BI-RADS–MRI lexicon will increase the accuracy of interpretation of breast MRI images obtained at institutions worldwide.

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