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Characterization of the enhancing lesions on dynamic contrast enhanced magnetic resonance imaging in patients with interstitial mammoplasty

Tae Yun Kim [a], Sung Hun Kim [a,*], Bong Joo Kang [a], Hyeon Sook Kim [b], Eun Suk Cha [c], Ji Youn Kim [d], Byung Joo Song [e]

[a] Department of Radiology, Seoul St. Mary's Hospital, The Catholic University of Korea, Republic of Korea
[b] Department of Radiology, St. Paul Hospital, The Catholic University of Korea, Republic of Korea
[c] Department of Radiology, Ewha Womans University, School of Medicine, Mokdong Hospital, Republic of Korea
[d] Department of Radiology, Yeouido St. Mary's Hospital, The Catholic University of Korea, Republic of Korea
[e] Department of Surgery, Seoul St. Mary's Hospital, The Catholic University of Korea, Seoul, Republic of Korea

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ABSTRACT

Purpose: The purpose of this study was to categorize the morphologic and kinetic features of enhancing lesions in breasts with interstitial mammoplasty using dynamic contrast-enhanced magnetic resonance imaging and to assess factors predictive of breast cancer.
Materials and methods: We retrospectively reviewed the clinical and radiological data of 21 enhancing lesions in 19 patients with interstitial mammoplasty, who underwent breast magnetic resonance imaging and biopsy or an operation in our hospital from September 2008 to July 2012. These lesions were sorted by morphological and kinetic features and final assessment category according to the BI-RADS lexicon.
Results: Nine cases were confirmed to be ductal carcinoma in situ ($n=2$) and invasive ductal carcinoma ($n=7$), and the remaining 12 cases were fibrocystic disease ($n=2$), fibroadenoma ($n=2$), fat necrosis ($n=1$), foreign body granuloma ($n=3$) and silicone mastitis ($n=1$).

Common features of malignancy included irregular shape (50.0%), spiculated margins (75.0%), heterogeneous enhancement (50.0%) and type III kinetic pattern (87.5%). The correlations of margins and kinetic curve pattern with benignity and malignancy approached statistical significance ($p=0.02$, respectively). We found no correlation for shape ($p=0.33$) or internal enhancement ($p=0.42$) between lesion types. The malignancy rate of enhancing lesions was 42.8% (9/21). The sensitivity and specificity of dynamic contrast-enhanced magnetic resonance imaging were 100% and 16.67%, respectively. The positive predictive value, negative predictive value and accuracy of magnetic resonance imaging were 47.38%, 100% and 52.38%. Overall inter-observer agreement for the kinetic curve pattern was good ($\kappa=0.67$). Moderate agreement was seen in describing the shape, margin, enhancement and assessing the final category ($\kappa=0.59$, 0.46, 0.58 and 0.49, respectively).
Conclusion: Dynamic contrast-enhanced magnetic resonance imaging had a high sensitivity, negative predictive value for the prediction of breast cancer but a low specificity due to features of foreign body-related lesions that mimicked malignant lesions. The significant predictive factors for malignancy were margins, kinetic curve pattern and final assessment category. Overall inter-observer agreement for the kinetic curve pattern was good.

1. Introduction

Many different techniques for cosmetic breast augmentation were developed during the past decades to improve the size and form of breasts. Direct injection of liquid silicone or paraffin into the breast parenchyma was a relatively inexpensive and simple method of mammoplasty [1]. Although the direct silicone injection technique was banned in the United States by the U.S. Food and Drug Administration (FDA) [2], the interstitial injection of silicone or paraffin into the breast parenchyma was illegally performed during the 1950s and 1960s, particularly in Mexico and Asia [3].

Complications of interstitial mammoplasty, such as chronic inflammation or fibrosis, may induce hard, nodular breast masses or structural distortion mimicking breast cancer. Therefore, it

* Corresponding author at: Department of Radiology, Seoul St. Mary's Hospital, The Catholic University of Korea, 505 Banpo-Dong, Seocho-Ku, Seoul 137-040, Republic of Korea. Tel.: +82 2 2258 1453; fax: +82 2 599 6771.
E-mail address: rad-ksh@catholic.ac.kr (S.H. Kim).

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is important to evaluate the assessment of these patients [2,4]. Injected silicone and paraffin droplets are observed as scattered, hyperdense nodules on mammography and multiple, low echogenic lesions with strong echogenic posterior shadow on ultrasonography (USG), which inhibit the detection of pathologic lesions [5–7]. Dynamic contrast enhanced magnetic resonance imaging (DCE-MRI) is an ideal imaging tool for the detection of true pathologic lesions due to its high temporal and spatial resolution. Furthermore, angiogenic pathologic lesions can be differentiated from non-angiogenic siliconoma or paraffinoma by the administration of contrast agent [7,8]. Few articles regarding MRI for patients with interstitial mammoplasty have been published [4,6–8]. To the best of our knowledge, no previous published study has used MRI lexicon and final assessment according to BI-RADS to characterize enhancing lesions in patients with interstitial mammoplasty. We used MRI to characterize enhancing lesions in patients with interstitial mammoplasty, and included a relatively large number of cases ($n = 21$).

The purpose of this study was to categorize the morphologic and kinetic features of enhancing lesions in breasts with injected foreign bodies using DCE-MRI according to the BI-RADS lexicon and to assess predictive factors for breast cancer.

2. Materials and methods

2.1. Patients

Our ethics committee approved this retrospective study and waived the requirement for informed consent. From September 2008 to July 2012, we retrospectively reviewed the clinical and radiological data of 19 patients aged 37 and 76 years old (mean age, 56 years) with interstitial mammoplasty for the cosmetic purpose, who underwent breast MRI and had enhancing lesions with pathologic confirmation in our hospital. Three out of 19 patients had high risk for breast cancer (2: familial history, 1: previous breast cancer). DCE-MRI was recommended in patients with interstitial mammoplasty due to impossible and incomplete evaluation on mammography and USG or after US guided pathology confirmation on the palpable mass. Two patients, who had scattered injection granulomas in the retromammary fat layer, showed suspicious mass on mammography. Among the two masses, one was easily detected but the other was difficult to be differentiated from surrounding injection granulomas on USG. Pathology was confirmed by MR ($n = 15$) or USG-guided biopsy ($n = 4$) or an operation ($n = 2$). The clinical history was reviewed, including the date of the injection and the symptoms and signs at presentation.

2.2. MRI imaging acquisition

MR imaging was performed in a prone position using a dedicated bilateral breast surface coil (3 T MRI in 13 patients and 1.5 T MRI in 6 patients). Imaging with a 3 T MRI system (Verio; Siemens Healthcare, Erlangen, Germany) was obtained using the following sequences: (1) an axial, turbo spin-echo T2-weighted imaging (T2WI) sequence with a TR/TE of 4530/93, a flip angle of 80°, 34 slices, an FOV of 320 mm, a matrix size of 576 × 403, 1 NEX, a slice thickness of 4 mm and an acquisition time of 2 min 28 s; (2) pre- and post-contrast, axial T1-weighted flash three-dimensional VIBE sequences with a TR/TE of 4.4/1.7, a flip angle of 10°, a slice thickness of 1.2 mm and an acquisition time of 7 min 7 s. The images were obtained before and at 7, 67, 127, 187, 247 and 367 s after an injection of Gd-DPTA (0.1 mmol/kg Gadovist; Bayer Schering Parma, Berlin, Germany). Imaging performed with a 1.5 T MRI system (Signa; GE Medical Systems; Milwaukee, WI, USA) was conducted using the following sequences: (1) axial, fat-suppressed, fast spin-echo T2WI (TR/TE = 4000/85, a flip angle of 90°, 30 slices, a field of view [FOV] of 240 mm, a matrix of 256 × 224, a number of excitations [NEX] of 2, a 3-mm slice thickness with a 0.1 mm slice gap and an acquisition time of 2 min 56 s); (2) pre- and post-contrast, axial spin-echo T1WI (TR/TE = 625/12, a flip angle of 90°, 31 slices, an FOV of 300 mm, a matrix of 256 × 192, 1.5 NEX and an acquisition time of 3 min 56 s).

2.3. Imaging analysis and statistical analysis

Three radiologists with different levels of experience in breast MRI interpretation (KHS with 15 years' experience, KSH with 8 years' experience, KJY with 3 years' experience) independently interpreted the examinations. A consensus result was obtained using the agreement of more than two radiologists for a particular feature of each lesion. In case with no agreement of three radiologists, they reached consensus. The morphologic features and kinetic curves of enhancing lesions were pathologically confirmed and classified using terminology according to the American College of Radiology (ACR) BI-RADS®. The assessment items of the morphologic features in 20 enhancing masses from 18 patients included shape, margins and internal enhancement. Distribution and internal enhancement were assessed in one non-mass enhancing lesion in one patient. Enhancement kinetics were evaluated with a kinetic curve analysis ($n = 17$). Three basic curve shapes were used: type I curve (slow and steady enhancement over approximately 5 min), type II curve (early strong enhancement with a subsequent plateau phase) and type III curve (early strong enhancement with a subsequent decline in enhancement) [9]. Based on these, three radiologists reported a final assessment of the enhancing lesions according to the ACR BI-RADS® to evaluate the probability of malignancy. The level of suspicion was reported on a scale of 1–5 (C1, no abnormal enhancement or no lesion found; C2, benign, no malignant features; C3, probably benign; C4a, low suspicion of malignancy; C4b, intermediate suspicion of malignancy; C4c, moderate concern of malignancy; C5, highly suggestive of malignancy). Additionally, the recorded data included signal intensity of the adjacent muscle on T2WI (hypointense, isointense, hyperintense). The MRI data of enhancing lesions collected in this manner were correlated with pathologic data.

Statistical analyses were performed by using statistical software (MedCalc, version 12, Mariakerke, Belgium) with the chi-square test. An error probability of $p < 0.05$ was considered significantly significant. The sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV) and accuracy of MRI were calculated. BI-RADS categories 1–3 were grouped as benign and categories 4a–5 were considered malignant. The two categories were correlated with the pathologic conclusion.

The agreements among three readers were examined using the coefficient for inter-rater agreement (Cohen kappa). The interpretation was translated into five scales: poor (less than 0.2), fair (0.21–0.4), moderate (0.41–0.60), good (0.61–0.80) and very good (0.81–1.00) [10]. This was performed using the SAS software (version 9.1, SAS Institute Inc., Cary, NC).

3. Results

The mean time interval between interstitial mammoplasty and MRI was 19 years (range, 3–40 years). Liquid silicone was injected in four patients, liquid paraffin was injected in two patients, and the injection materials were unknown for 13 patients. 12 patients (64%) visited for a screening examination, three (16%) presented with a