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Role of Diffusion-Weighted Imaging and Apparent Diffusion Coefficient in Differentiating between Local Tumor Recurrence and Benign Breast Changes after Breast Conservative Surgery

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Received: 6 December 2013 Accepted: 2 January 2014 Published: 15 January 2014

Abstract

To assess the role of DWI and the ADC in differentiating between local tumor recurrence and benign breast changes after breast conservative surgery.Materials and Methods: 26 patients (age range, 25-68 years; mean age, 49 years) with breast conservation surgery were included in our study. MRI study was done using bilateral fatsuppressed T2-weighted fast spin-echo, axial STIR, axial T1-weighted fast spin-echo. DWI series were acquired using echo planar imaging pulse sequences incorporating with diffusion gradients and finally dynamic contrast enhancement study was done.Results: Among the twenty sex patients underwent MR imaging in our study, 7 patients were diagnosed at histopathology as local tumor recurrence at the site of surgery, and 11 patients had surgical scarring, 6 patients had seromas, one patient had hematoma and one patient had fat necrosis.

Index terms— diffusion-weighted imaging, apparent diffusion coefficient, breast lesions.

1 Introduction

ith breast conservation therapy, the rate of recurrence is low but not zero. The statement that outcomes in women who undergo breast conservation are equivalent to the outcomes in women who undergo mastectomy is debatable. The trials that have been performed to date have shown that women who undergo breast conservation have a higher risk of local recurrence. Thus, disease free survival is not equivalent (1). It was previously thought that local recurrence did not affect overall survival. However, it is now well accepted that local relapse does affect overall survival. Therefore, preventing local recurrence is considered as important as the early diagnosis of the primary breast cancer. The ability to prevent local recurrence requires more accurate staging and subsequent treatment; this is where MRI can play a critical role (2,3,4).

Architectural distortion and increased density at the lumpectomy site as well as post-treatment edema may impair accurate detection of recurrence at mammography and ultrasonography (US). Localregional recurrences occur in approximately 5% of patients at 5 years with a local failure rate of approximately 1%-2.5% per year. In the immediate postoperative period, suspicious findings likely represent residual disease, whereas local recurrence typically occurs 3-7 years after breast conservation therapy. Early detection of local recurrence of breast cancer has been shown to significantly improve longterm survival (5).

Dynamic contrast material-enhanced magnetic resonance (MR) imaging has been shown to aid significantly in detection and characterization of primary and recurrent breast cancers (6,7). The sensitivity of breast MR imaging for detection of residual and recurrent tumor in the post-breast conservation therapy is over 90% (8.9). Breast MR imaging has been shown to be useful in differentiating scar tissue from tumor recurrence; in particular, non-enhancing areas have a high negative predictive value for malignancy (88%-96%) (10,11).

Currently, there is much variability in use of breast MR imaging to follow up women after breast conservative therapy. The practice guidelines of the American College of Radiology state that breast MR imaging may be

useful in women with a history of breast cancer and suspicion of recurrence when clinical, mammographic, or sonographic findings are

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Global Journal of Global Journal of diagnosis of breast cancer are at increased risk for a second diagnosis, an American Cancer Society panel concluded that the increased risk due to a personal history of breast cancer alone does not justify a recommendation for overall screening with MR imaging in women who have undergone breast conservation therapy (13).

Currently one of the most important indications for MRI is the differential diagnosis between cancer recurrence and surgical scar. In fact, breast MRI has become a common practice in the evaluation for recurrence of breast cancer. Both surgery and radiation can cause scarring with architectural distortion of the breast, which makes assessment of local recurrence difficult by means of clinical examination, mammography, and ultrasound. Post-treatment changes can mimic malignancy or obscure locally recurrent breast cancer. For these reasons, breast MRI is a useful tool in the evaluation of such patients (14,15,16).

Diffusion-weighted imaging (DWI) is an unenhanced MRI sequence that measures the mobility of water molecules in vivo and provides different and potentially complementary information to (Dynamic Contrast Enhancement) DCE-MRI. DWI is sensitive to biophysical characteristics of tissues, such as cell density, membrane integrity, and microstructure. Promising findings from preliminary DWI studies of the breast have shown significantly lower apparent diffusion coefficient (ADC) measures for breast carcinomas than for benign breast lesions or normal tissue [17][18][19][20][21][22][23]. The lower ADC in malignancies is primarily attributed to higher cell density causing increased restriction of the extracellular matrix and increased fraction of signal coming from intracellular water [17,18,24]. A recent study reported high accuracy for characterizing enhancing breast masses through a multivariate combination of DWI and DCE-MRI features [25].

3 II.

4 Objective

The aim of our study was to assess the role of DWI and the ADC in differentiating between locoregional tumor recurrence and benign breast changes after breast conservative surgery.

5 III.

6 Material & Method a) Patients

Between June 2009 and February 2013, 26 patients (age range, 25-68 years; mean age, 49 years) with breast conservation surgery (lumpectomy & partial mastectomy) were included in our study. Patients were imaged using conventional MRI, DWI and DCE-MRI before biopsy of their breast lesion. Approval for the study was obtained from the local ethical committee in the Al-Noor specialist hospital, in Holey Makkah. Written informed consent was obtained from all patients before MRI. In all patients, MRI was performed bilaterally.

Examinations were excluded if no diffusion weighted imaging had been performed, no measurable mass on DWI or less than one year of follow-up is not available.

7 b) MRI technique

MRI examinations were performed using a 1.5-T MRI scanner (Magnetom Espree, Siemens Healthcare). Patients were examined in the prone position using a dedicated 4-channel phased array bilateral breast coil. Before administration of contrast media, axial bilateral fat-suppressed T2-weighted fast spin-echo, axial STIR, axial T1-weighted fast spin-echo and DWI series were acquired.

DW image was performed in axial slice orientation using echo planar imaging pulse sequences incorporating with diffusion gradients. DW EPI with fat suppression was applied using TR/TE of about 8400/98 ms, FOV of 340 x 170 mm, matrix: 192 x 96 and a slice thickness of 4 mm. Spectral pre-saturation with inversion recovery (SPAIR) was used for fat suppression. An acceleration factor of two was applied using the generalized auto-calibrating partially parallel acquisition (GRAPPA) of parallel imaging technique. Motion-probing gradients in three orthogonal orientations were applied with b values of 50, 400 and 800 using 3-scan trace calculation. Isotropic diffusion-weighted (trace) images were reconstructed for each b value. For quantitative analysis of the data acquired from DWI, ADC maps were automatically created using software provided by the MRI system manufacturer (Syngo, Siemens Healthcare) using three b values (50, 400, and 800 s/mm2). We apply the DW sequences prior to the dynamic scan as the T1 relaxation due to the contrast agent will cause changes to the inversion of the tissue and thus can have a strong impact.

Finally, dynamic axial bilateral breast images of fat-suppressed high-resolution T1-weighted 3D fast gradient-echo images were sequentially acquired. Five measurements were acquired one before and four after the administration of contrast media. For the dynamic study, gadopentetate dimeglumine (Magnevist) was administered IV using a power injection at a dose of 0.1 mmol /kg of body weight at a flow rate of 2 mL/s, followed by flushing with 25 mL of saline. The parameters were as follows: TR/TE 4.2/1.6; flip angle 15°; FOV

340 × 340 mm; matrix 512 × 410; thickness 0.9 mm; acquisitions 1; and acquisition time 110 seconds. SPAIR for fat suppression and a GRAPPA acceleration factor of two for parallel imaging technique were also applied. DCE was done in 25 cases and contraindicated in one patient with renal failure on hemodialysis with GFR less than 30Ml/min.

8 IV.

9 Results

Among the twenty sex patients undergoing MR imaging in our study, diagnosis of local tumor had surgical scarring, six patients had seromas, one patient had hematoma and one patient had fat necrosis.

According to the ADC values (Table 1) seven lesions were local tumor recurrence (Fig. 1 and Fig. **??**), and showed mean ADC values of 0.95 ± 0.37 x 10-3 mm2/s and ADC range of (0.76 -1.33 x 10-3 mm2/s).

In our study nineteen lesions were benign; 11 lesions were post-operative scarring (Fig. **??**) and showed mean ADC values of 1.66 ± 0.28 x 10-3 mm2/s and ADC range of (1.35 -1.86 x10-3 mm2/s), 6 lesions were seromas (Fig. **??**) and showed mean ADC values of 2.21 ± 0.15 x 10-3 mm2/s and ADC range of (2.13-2.73 x 10-3 mm2/s), one lesion were hematoma (Fig. **??**) and showed mean ADC values of 0.39 ± 0.16 x 10-3 mm2/s and ADC range of (0.34 -0.56 x 10-3 mm2/s) and one lesion was fat necrosis (Fig. **??**) and showed mean ADC values of 0.141 ± 0.26 x 10-3 mm2/s and ADC range of (1.22 -0.161 x 10-3 mm2/s). All cases of local tumor recurrence in our study showed lower ADC values than benign lesions with ADC range of 0.76 -1.33 x 10-3 mm2/s (mean ADC = 0.95 ± 0.37 x 10-3 mm2/s) and were diagnosed pathologically as malignant breast lesions. All benign lesions showed higher ADC values with a range from 1.22-2.73 x 10-3 (mean ADC = 1.69 ± 0.16 x 10-3 mm2/s) except one case of hematoma showed lower ADC value (0.34 -0.56 x 10-3 mm2/s) and was diagnosed by conventional MRI. Figure **??**even shows box plots graphs of range and mean apparent diffusion coefficient (ADC) values for local regional neoplastic tumor recurrence and benign breast changes after breast conservation therapy in our study.

In our study, using a cutoff point 1.35 x 10-3 mm2/s, the sensitivity, and specificity for DWI in the differentiating local tumor recurrence from benign breast lesions were 100 % and 94.7 %, respectively and total accuracy of about 96.2 %.

10 V.

11 Discussion

Breast MRI is the widely accepted diagnostic approach for evaluating the breast. To improve the sensitivity of detecting breast cancer, several diverse techniques are used for breast MRI (21). In particular, dynamic-enhanced MRI provides for evaluating multiple foci of carcinoma in the breast and it displays extremely high sensitivity for identifying breast cancer. However, dynamic-enhanced breast MRI has some disadvantages such as being time-consuming and costly, the possible side effects of the contrast media and the relative low specificity compared to mammography and ultrasonography (26,27,28).

Generally in biologic tissues, microscopic motion includes both the molecular diffusion of water and the blood microcirculation in the capillary network, and both diffusion and perfusion affect the ADC values. Because of the extent of micro-vessels in malignant breast tumor, the ADC value can be strongly affected by perfusion when the b value is small. A previous report insisted that b-values less than 750 s/mm2 are most effective for detecting breast tumors (29). However, we used EPI with a b-value up to (800 s/mm2) so we could obtain diffusion effects without significant image distortion.

In addition to conventional MRI, DWI has been reported as a useful technique for the discrimination between benign and malignant breast lesions (17,21,22). We believe that DWI has a potential role in improving the diagnostic performance of breast MRI. Our findings show that a quantitative analysis of ADC values can be used to distinguish local tumor recurrence from benign breast changes after conservative surgery. In our study, all cases of local tumor recurrence show high signal intensity on DWI and low ADC value on ADC map (Fig. 1 and Fig. **??**) with mean ADC values of 0.95 ± 0.37 x 10 -3 mm2/s and ADC range of (0.76 -1.33 x 10-3 mm2/s) which is in accordance with recent study (30).

All cases of post-operative scarring in our study show low signal intensity on DWI and high SI on ADC map (Fig. **??**) with high ADC values than local tumor recurrence. The mean ADC values of scars in our study measures 1.66 ± 0.28 x 10 -3 mm2/s with ADC range of about 1.35 -1.86 x10-3 mm2/s. Multiple studies (31,32) stated that postoperative granulation tissue had a high ADC value (2.66× 10 -3 mm2/s) which in agreement with our study. Recent meta-analysis has determined that an ADC value > 1.2 x 10 -3 mm2/sec speaks for benignancy (33) and other recent study (34) stated that The average ADC for scar tissue was 1.89 x 10 -3 mm2/s and ADC range of about 1.43 -2.20 X 10 -3 which are in accordance with our results.

All cases of seromas in our study are hypointense on T1W imaging, hyperintense on T2W imaging, and displays smooth peripheral enhancement (< 4 mm thickness) with contrast and show free diffusion with mean ADC values of 2.21 ± 0.15 x 10 -3 mm2/s and ADC range of (2.13-2.73 x 10 -3 mm2/s) which in agreement of previous studies (31,33,35) In our study there is one case of hematoma with false positive result on DWI with local tumor recurrence with mean ADC values of 0.39 ± 0.16 x 10 -3 mm2/s and ADC range of 0.34 -0.56 x

10 -3 mm2/s. However the lesion was diagnosed as hematoma from conventional MRI as the lesion displayed hyperintense on T1W imaging, hypointense on T2W imaging, and shows minimal smooth marginal contrast enhancement which in accordance with previous studies (30,35).

In our case of fat necrosis, enhancement was heterogeneous and associated with oval smooth mass of fat signal intensity. On DWI, it showed low SI on DWI & high SI on ADC map except the fatty area and showed mean ADC values of 1.41 ± 0.26 x 10 -3 mm2/s and ADC range of (1.22 -0.161 x 10 -3 mm2/s) which in agreement with recent studies (30, **??**6).

In our study, using a cutoff point of 1.35 x 10 -3 mm2/s the sensitivity, and specificity for DWI in the differentiating local tumor recurrence from benign breast lesions were 100 % and 94.7 %, respectively. The sensitivity & specificity of diffusion WI in differentiating local tumor recurrence from benign breast lesions in our study is in agreement with previous studies (19,25,30,32,37) which showed the sensitivity & specificity of DWI in the differentiation between benign and malignant breast lesions were ranging from 81% to 97%, and from 80% to 100% respectively.

12 VI.

13 In Conclusion

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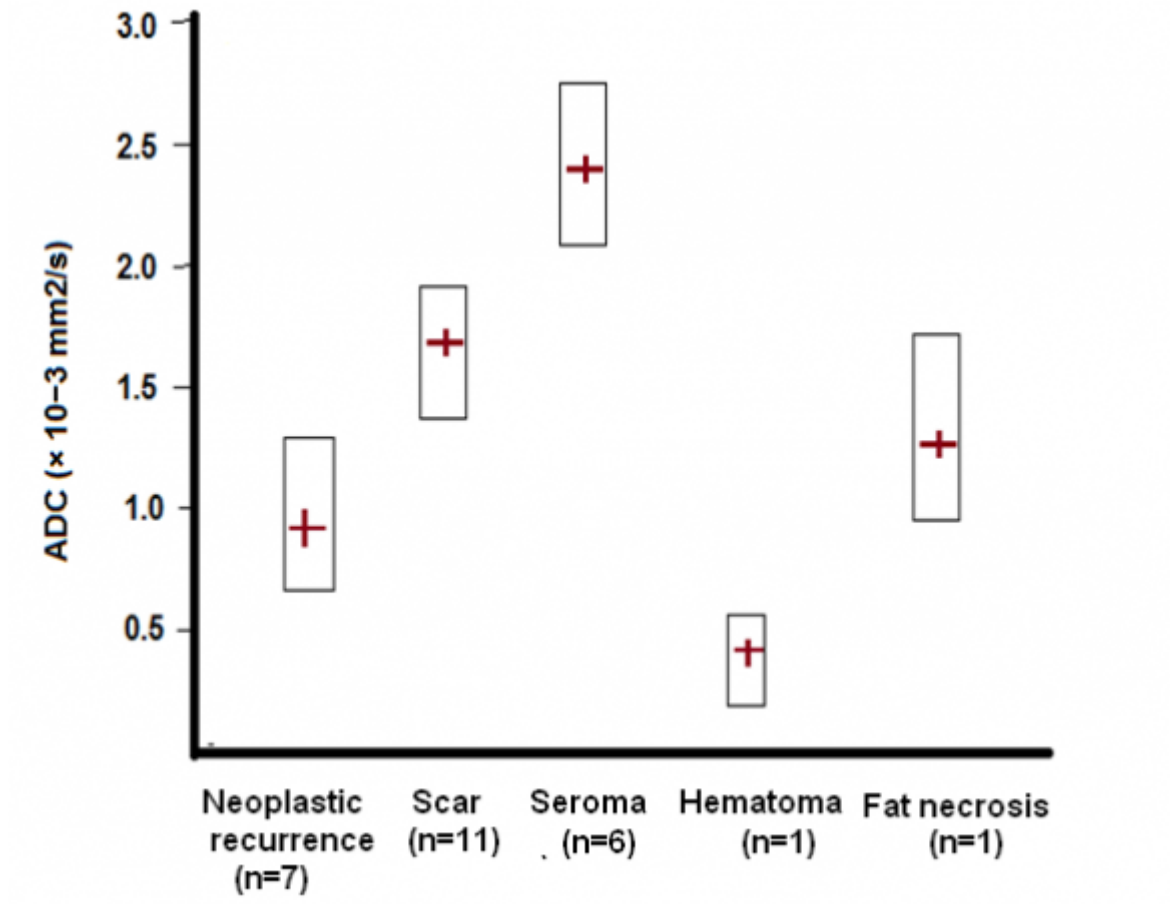
Figure 1: Fig. 7 :



1

Figure 2: Fig. 1 :

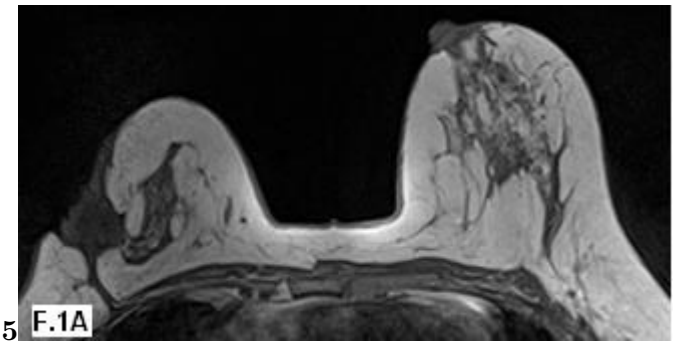


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Figure 3: Fig. 2 :Fig. 3 :Fig. 5 :D

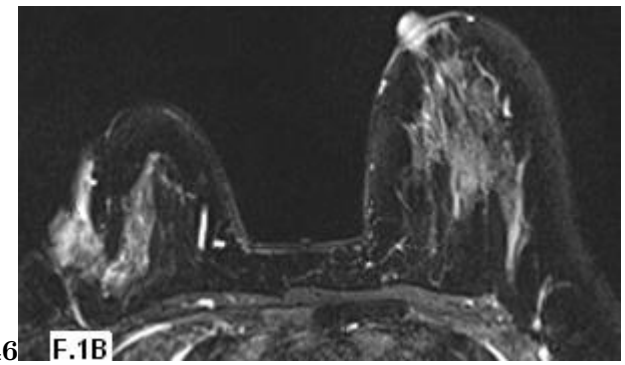

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Figure 4: Fig. 4 :Fig. 6 :

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Types of lesions		No. of lesions	ADC Values (× 10 -3 mm2/s)	
		N= 26	Range of ADC	Mean ADC
?	Local tumor recurrence	7	0.76 -1.33	0.95 ± 0.37
?	Scar tissue	11	1.35 -1.86	1.66 ± 0.28
?	Seromas	6	2..13 -2.73	2.21 ± 0.33
?	Hematoma	1	0.34 -0.56	0.39 ± 0.16
?	Fat necrosis	1	1.22 -0.161	1.41 ± 0.26

Figure 5: Table 1 :

[College and Radiology ()] *ACR practice guideline for the performance of contrast enhanced magnetic resonance imaging (MRI) of the breast*, American College , Radiology . 2008. Reston, Va: American College of Radiology.

[Woodhams et al. ()] 'ADC mapping of benign and malignant breast tumors'. R Woodhams , K Matsunaga , S Kan . *Magn Reson Med Sci* 2005. 4 p. .

[Saslow et al. ()] 'American Cancer Society guidelines for breast screening with MRI as an adjunct to mammography'. D Saslow , C Boetes , W Burke . *CA Cancer J Clin* 2007. 57 (2) p. .

[Hatakenaka et al. ()] 'Apparent diffusion coefficients of breast tumors: clinical application'. M Hatakenaka , H Soeda , H Yabuuchi . *Magn Reson Med Sci* 2008. 7 p. .

[Jacobs et al. ()] 'Benign and malignant breast lesions: diagnosis with multiparametric MR imaging'. M A Jacobs , P B Barker , D A Bluemke , C Maranto , C Arnold , E H Herskovits . *Radiology* 2003. 229 p. .

[Schnall et al. ()] 'Diagnostic architectural and dynamic features at breast MR imaging: multicenter study'. M D Schnall , J Blume , D A Bluemke . *Radiology* 2006. 238 (1) p. .

[Schnall et al. ()] 'Diagnostic architectural and dynamic features at breast MR imaging: multicenter study'. M D Schnall , J Blume , D A Bluemke . *Radiology* 2006. 238 p. .

[Guo et al. ()] 'Differentiation of clinically benign and malignant breast lesions using diffusion-weighted imaging'. Y Guo , Y Q Cai , Z L Cai . *J Magn Reson Imaging* 2002. 16 p. .

[Wenkel et al. ()] 'Diffusion weighted imaging in breast MRI: comparison of two different pulse sequences'. E Wenkel , C Geppert , R Schulz-Wendtland . *Acad Radiol* 2007. 14 p. .

[Kuroki et al. ()] 'Diffusion weighted imaging of breast cancer with the sensitivity encoding technique: analysis of the apparent diffusion coefficient value'. Y Kuroki , K Nasu , S Kuroki . *MagnReson Med Sci* 2004. 3 p. .

[Ranildi et al. ()] 'DWI in breast MRI: Role of ADC value to determine diagnosis of tumor between tumor recurrence and surgical scar in operated patients'. P Ranildi , M Giulaini , B Belli . *European journal of radiology* 2010. 2 p. .

[Kinkel et al. ()] 'Dynamic high-spatial resolution MR imaging of suspicious breast lesions: diagnostic criteria and interobserver variability'. K Kinkel , T H Helbich , L J Esserman . *AJR Am J Roentgenol* 2000. 175.

[Poggi et al. ()] 'Eighteen-year results in the treatment of early breast carcinoma with mastectomy versus breast conservaon therapy: the Naonal Cancer Instute randomized trial'. M M Poggi , D N Danforth , L C Sciuto . *Cancer* 2003. 98 p. .

[Yabuuchi et al. ()] 'Enhanced mass on contrast-enhanced breast MR imaging: lesion characterization using combination of dynamic contrast-enhanced and diffusion-weighted MR images'. H Yabuuchi , Y Matsuo , T Okafuji . *J Magn Reson Imaging* 2008. 28 p. .

[Gonzales et al. ()] M A Gonzales , Castañon A I , Baltar B N . *Diffusion weighted MR Imaging assessment after breast conservative treatment*, 2012. p. 1065.

[Dhillon et al. ()] 'Imaging Assessment of the Breast after Breast Conservation Therapy: Distinguishing Benign from malignant lesions'. G S Dhillon , N Bell , D T Ginat . *Clin imaging sci* 2011. 2012. 1 (48) p. . (Radiographics)

[Sinha et al. ()] 'In vivo diffusion-weighted MRI of the breast: potential for lesion characterization'. S Sinha , F A Lucas-Quesada , U Sinha , N Debruhl , L W Bassett . *J Magn Reson Imaging* 2002. 15 p. .

[Fowble and Schwaibold (ed.) ()] *Local-regional recurrence following definitive treatment for operable breast cancer*, B Fowble , F Schwaibold . Fowble B, Goodman RL, Glick JH, Rosato EF (ed.) 1991. St Louis, Mo: Mosby -Year Book. p. . (Breast cancer treatment: a comprehensive guide to management)

[Vandongen et al. ()] 'Long-term results of a randomized trial comparing breast-conserving therapy with mastectomy: European Organizaon for Research and Treatment of Cancer 10801 trial'. J A Vandongen , A C Voogd , I S Fenman . *J Natl Cancer Inst* 2000. 92 p. .

[Doyle et al. ()] 'Long-term results of local recurrence aer breast conservaon treatment for invasive breast cancer'. T Doyle , D J Schultz , C Peters . *Int J Radiat Oncol Biol Phys* 2001. 51 p. .

[Tsushima ()] 'Magnetic resonance (MR) differential diagnosis of breast tumors using apparent diffusion coefficient (ADC) on 1.5 T'. Y Tsushima . *JMRI* 2009. 30 p. .

[Ikeda et al. ()] 'Magnetic resonance imaging of breast cancer : clinical indications and breast MRI reporting system'. D M Ikeda , D R Baker , B L Daniel . *J MagnReson Imaging* 2000. 12 p. .

[Bluemke et al. ()] 'Magnetic resonance imaging of the breast prior to biopsy'. D A Bluemke , C A Gatsonis , M H Chen . *JAMA* 2004. 292 p. .

[Preda et al. ()] 'Magnetic resonance mammography in the evaluation of recurrence at the prior lumpectomy site after conservative surgery and radiotherapy'. L Preda , G Villa , S Rizzo . *Breast Cancer Res* 2006. 8 (5) p. R53.

[Lyng et al. ()] 'Measurement of cell density and necrotic fraction in human melanoma xenografts by diffusion weighted magnetic resonance imaging'. H Lyng , O Haraldseth , E K Rofstad . *Magn Reson Med* 2000. 43 p. .

[Orel and Schnall ()] 'MR imaging of the breast for the detection, diagnosis, and staging of breast cancer'. S G Orel , M D Schnall . *Radiology* 2001. 220 p. .

[Frei et al. ()] 'MR imaging of the breast in patients with positive margins after lumpectomy: influence of the time interval between lumpectomy and MR imaging'. K A Frei , K Kinkel , H M Bonel , Y Lu , L J Esserman , N M Hylton . *AJR Am J Roentgenol* 2000. 175 (6) p. .

[Kelcz and Hain ()] 'Post Lumpectomy MRI: using diffusion weighted imaging (DWI) to distinguish benign from malignant tissues'. F Kelcz , K S Hain . *Mag. Reson. Med* 2010. 18 p. 4535.

[Rubesova et al. ()] 'Quantitative diffusion imaging in breast cancer: a clinical prospective study'. E Rubesova , A S Grell , De Maertelaer , V Metens , T Chao , S L Lemort , M . *J Magn Reson Imaging* 2006. 24 p. .

[Marini et al. ()] 'Quantitative diffusionweighted MR imaging in the differential diagnosis of breast lesion'. C Marini , C Iacconi , M Giannelli , A Cilotti , M Moretti , C Bartolozzi . *Eur Radiol* 2007. 17 p. .

[Jatoil and Ma ()] 'Randomized trials of breast-conserving therapy versus mastectomy for primary breast cancer: a pooled analysis of updated results'. Proschan Jatoil , Ma . *Am J Clin Oncol* 2005. 28 p. .

[Viehweg et al. ()] 'Retrospective analysis for evaluation of the value of contrast-enhanced MRI in patients treated with breast conservative therapy'. P Viehweg , A Heinig , D Lampe , J Buchmann , S H Heywang-Köbrunner . *MAGMA* 1998. 7 (3) p. .

[Drew et al. ()] 'Routine screening for local recurrence following breastconserving therapy for cancer with dynamic contrast-enhanced magnetic resonance imaging of the breast'. P J Drew , M J Kerin , L W Turnbull . *Ann Surg Oncol* 1998. 5 (3) p. .

[?ahin ()] 'The role of apparent diffusion coefficient values in the differential diagnosis of breast lesions in diffusion-weighted MRI'. C ?ahin , Ar?balE . *Diagn Interv Radiol* 2013. 19 p. .

[Mi et al. ()] 'The Role of Diffusion-Weighted Imaging and the Apparent Diffusion Coefficient (ADC) Values for Breast Tumors'. J P Mi , S C Eun , J K Bong . *Korean J Radiol* 2007. 8 p. .

[Nunes et al. ()] 'Update of breast MR imaging architectural interpretation model'. L W Nunes , M D Schnall , S G Orel . *Radiology* 2001. 219 (2) p. .