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Core breast biopsy under MR control – preliminary results

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Summary

Background: Breast MR examination is capable of detecting suspected lesions that are not visualized by other imaging techniques, such as mammography or ultrasonography. In all cases such lesions should be verified histopathologically by MR-guided core biopsy.

The aim of the study was the determination of effectiveness of MR-guided breast core biopsy in detection of breast pathologies.

Material/Methods: Twelve women with suspected lesions detected by MR (GEMS Signa Excite 1.5 T with 4-channel open breast coil manufactured by MRI Devices Corporation) were qualified to MR-guided breast biopsy. Obtained image data were transferred to DYNACAD workstation for calibration, lesion localization, and automatic calculation of target coordinates for MR-guided intervention. Biopsy was performed using automated 14G biopsy needle.

Results: MR-guided breast biopsy was performed in 9 women and confirmed lobular and ductal carcinoma in 2 patients respectively, lobular carcinoma in situ (LCIS) in 1, intraductal papilloma in 2, and intraductal hyperplasia without atypia. In 3 patients histopathologic examination revealed benign fibrocystic lesions. Three women were disqualified from biopsy because pre-biopsy MR sequences did not reveal the lesion in 1 case, and due to the target localization out of reach of the biopsy needle in other 2 cases.

Conclusions: All non-palpable lesions visualized by MR (contrast-enhanced signal in dynamic examination) should be verified by MR-guided breast biopsy. In each case histopathologic findings should be compared with the pre-biopsy images (morphology and enhancement pattern).

Key words: Breast MR • MR breast biopsy • MR guided core breast core biopsy

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Background

Over the past ten years breast MR examination proved to be effective in detecting breast cancers. Until recently it has been applied as a complimentary examination to mammography and US, but today it often plays the deciding role in diagnostically uncertain cases [1].

MR mammography is characterized by high sensitivity in detection of pathological changes with lower specificity in diagnosing neoplastic lesions [2]. Due to relatively high cost it is not applied in routine breast diagnostics. Today the most common indications include: shedule breast conservative theraphy – BCT, follow-up after conservative operation, carrier state of BRCA1, BRCA2 or CHEK2 type gene

mutation which increase the risk for breast cancer, persistent hemorrhagic exudate from the nipple with no cause visible in other examinations, metastases to axillary lymph nodes of unknown origin, positive result of fine needle biopsy or core biopsy of breast without visualization of the lesion in the following imaging examinations [1, 2, 3].

A common denominator of all those cases is the possibility to detect a neoplastic focus invisible in other imaging examinations of breast – mammography, US or rarely galactography. However, having visualized the suspected lesion based only on the MR examination, it is extremely difficult to obtain a histopathologic result that would reliably define its character.

Therefore the MR breast examinations use the so-called open mammographic coils cooperating with localization devices (fig. 1, 2) and specialist software enabling to determine location of the lesion for insertion of the localized needle (in order to perform an open surgical biopsy] or to perform percutaneous MR-guided core biopsy [2, 4].

The aim of this study is to present self- experienced initial attempts to perform MR-guided core breast biopsy.

Materials and methods

The number of patients referred to breast magnetic resonance in whom only the MR showed suspected lesions, was 24 in total, mean age of 47. All of them previously underwent clinical examination, mammography (2 projections) and US (probe 7.5-12 Mhz) but none of the examination revealed focal lesions. The reason to refer women to the MR examination was a scheduled BCT in 9 women, carrier state of BRCA1 gene mutation in 11 women and in 4 patients- a follow-up after mastectomy. Hormone replacement theraphy (SHT) was taken by 8 women.

The MR showed suspected lesions and all 24 women underwent repeated US examination with another evaluation of previous mammography exams. In 12 of them the lesions presented in MR were visualized. Those women were referred to breast biopsy guided by US (11 patient) or mammography (1 patient).

In another 12 patients the repeated examinations did not show lesions found in MR. Those patients were referred to MR guided biopsy. Finally, biopsy was performed in 9 patients. The shortest period of time between the diagnostic MR and biopsy was 1 week and the longest – 1 month.

The diagnostic MR of breast was performed using MR system - GEMS Signa Excite 1.5 T with 4-channel open mammographic coil produced by MRI Devices Corporation. The investigations were conducted in two stages- first images were taken in frFSET2, FSET1, frFSET2+FS sequences in transverse planes and frFSET2

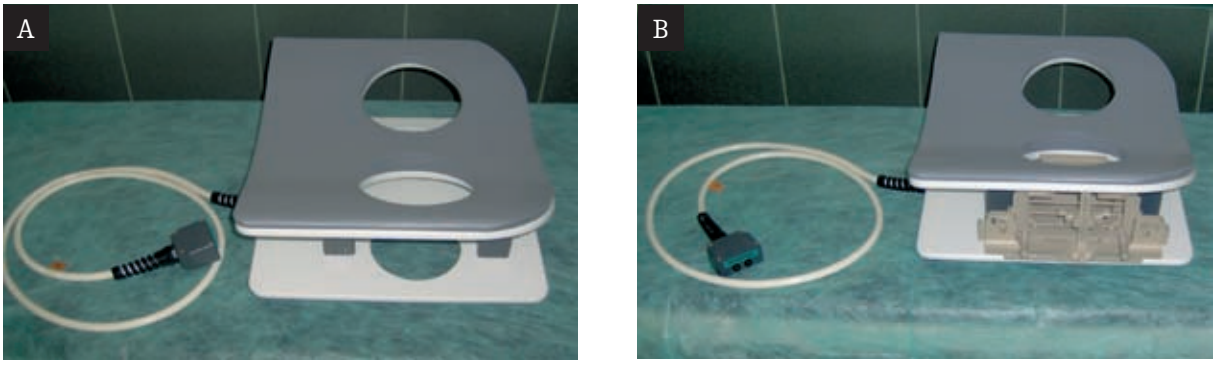


Figure 1. Breast MR coil **A**. Open breast coil allowing breast biopsy only from lateral access **B**. Open breast coil with immobilization and biopsy positioning device.

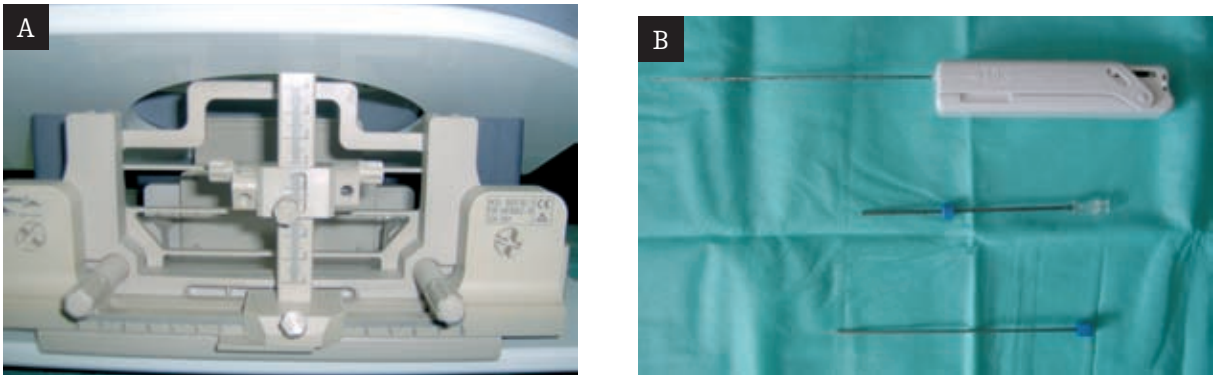


Figure 2. Breast biopsy set **A**. immobilization with biopsy positioning device – pillar system, allowing accurate needle guidance, according to already calculated coordinates (vertical, horizontal, depth and angulation) **B**. MR-compatible core biopsy kit 12G: automatic biopsy gun, coaxial needle and stylet.

in the sagittal plane. Additionally, in frontal layers in SE T1 sequence for assessment of axillary fossa before contrast agent administration. Afterwards a dynamic MR examination was performed in 3D T1 DYN sequence with 6-time repetition after contrast injection with the volume encompassing whole breasts and again in frontal planes in SE T1 sequence for evaluation of axillary fossa (table 1). In all cases we applied the Multihance contrast medium in a dose of 0,1 ml/kg of body mass.

After each examination the visualized focal lesions were evaluated morphologically and their signal enhancement curves were studied using the DynaCAD software.

During MR evaluation, the following parameters were taken into consideration:

1. Presence or lack of contrast enhancement of signal from focal lesion.

2. Morphokinetics of contrast enhancement:

– centripetal (lesion enhanced from periphery to the centre)

– centrifugal (lesion enhanced from centre to the periphery)

– homogenous (lesion enhanced homogenously)

– heterogeneous (lesion enhanced heterogeneously)

3. The level of maximum signal increase 1-3 minutes after intravenous contrast medium administration (early phase)

4. The level of maximum signal increase 3-6 minutes after contrast medium administration (late phase)

5. The shape of signal enhancement curve in both phases of dynamic imaging.

6. The presence or lack of contrast wash-out effect in the early phase

Table 1. MR sequences with their parameters applied in the examination.

Used sequenses	Parameters		
FSE T2 AX	TR: TE: Thk: SP: DFOV: MATRIX:	4840 83.2 5.0 mm 1.0 mm 32.9x32.9 512x512	ET: 16
FSE T2 + FAT SAT AX	TR: TE: Thk: SP: DFOV: MATRIX:	4600 84.4 5.0 mm 1.0 mm 32.9x32.9 512x512	ET: 18
FSE T1 AX	TR: TE: Thk: SP: DFOV: MATRIX:	520 10.3 5.0 mm 1.0 mm 32.9x32.9 512x512	ET: 4
FSE T2 SAG	TR: TE: Thk: SP: DFOV: MATRIX:	3260 83.2 5.0 mm 1.0 mm 24.0x24.0 512x512	ET: 18
T1 COR (węzły)	TR: TE: Thk: SP: DFOV: MATRIX:	520.0 10.3 5.0 mm 1.0 mm 37.9x37.9 512x512	ET: 4
3D T1 DYN AX	TR: TE: Thk: SP: DFOV: MATRIX:	3.6 1.0 4.0 mm 2.0 mm 33.9x33.9 512x512	ET: 0

Table 2. BI-RADS Classification.

	0 points	**1 point**	**2 points**
Shape of lesion	round or oval	spicular, irregular	-
Margins	circumscribed	ill-defined	-
Contrast enhancement	homogenous	heterogenous	rim
Initial contrast enhancement*	< 50%	50-100%	> 100%
Postinitial contrast enhancement in later phase**	continuous	plateau	wash-out effect especially over 10%

* early enhancement measured to 3 minutes after contrast agent administration; ** measured after 3 minutes from contrast administration.
Concerning the number of points of each lesion, it was qualified to one of the five groups:
Group I: 0 points, no lesions – routine examinations depending on age
Group II: 1-2 points, benign lesion – routine examinations depending on age
Group III: 3 points, lesion probably benign, next MR in 6 months
Group IV: 4-5 points, suspicious lesion – suggested biopsy
Group V: 6-8 points, lesion highly suspicious – necessary histopathologic verification

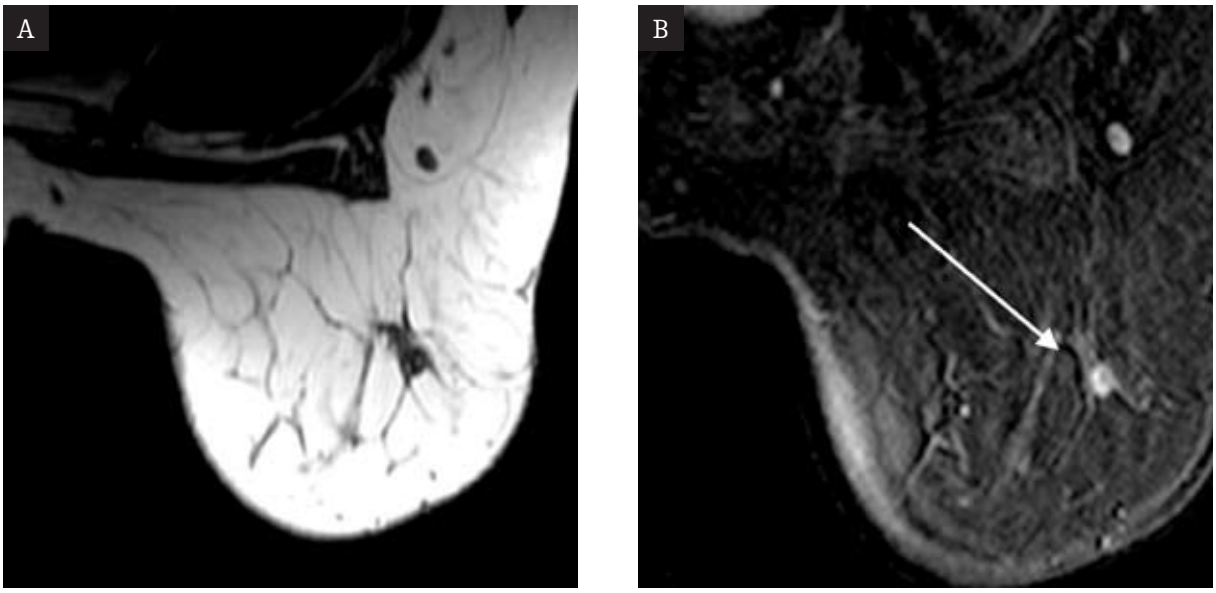


Figure 3. MR examination of the right breast **A**. image of the right breast in FSE T2 sequence **B**. right breast in dynamic 3D T1 sequence – image of the suspected lesion 2 minutes after contrast infusion – arrow.

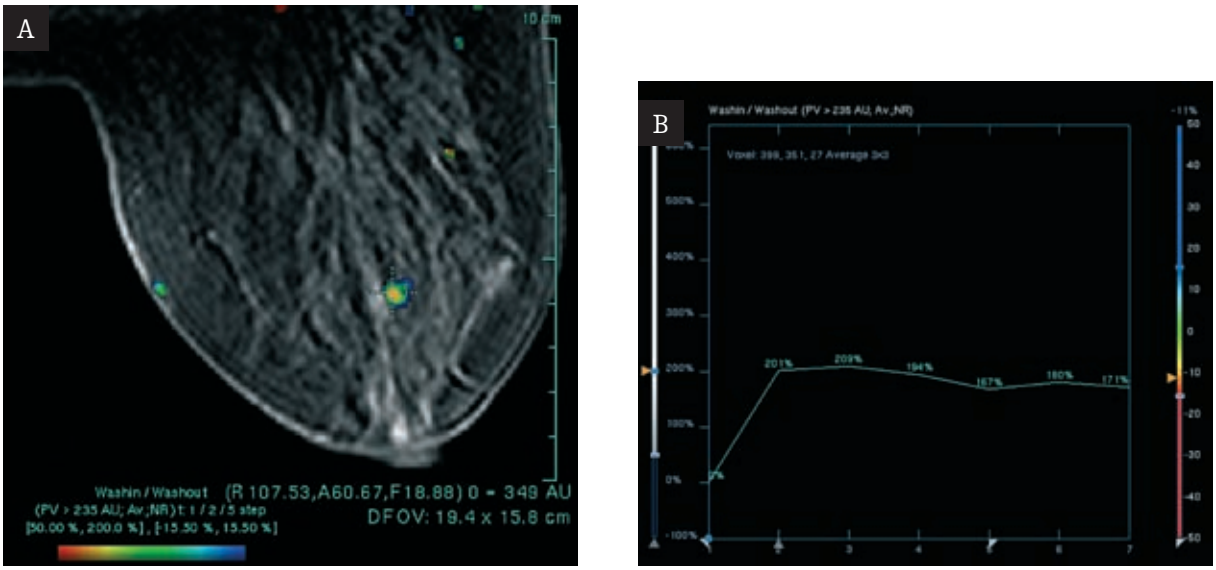


Figure 4. MR examination of the right breast, 3D T1 dynamic sequence with contrast **A**. suspected lesion of the right breast – post-processing image from Dynacad workstation; 3D T1 sequence with colour coded contrast enhancement **B**. dynamic contrast enhancement curve wash-in/ wash-out type, calculated for suspected lesion, wash-out – 11%.

Additionally, every visualized lesion was assessed using the BIRADS (Breast Imaging Reporting and Data System) for MR – table 2.

We decided that patients with lesions visualized in breast MR and qualified to group IV or V will be referred to MR-guided biopsy. Additionally, in a few first patients the biopsy will be carried out in patients with lesions qualified to group III.

The biopsy was given up in cases of multiple small disseminated areas of contrast enhancement observed in both breasts.

In order to perform a biopsy the patient was laid down in prone position in order to place the breasts inside the opened biopsy coil. Then the examined breast was put into a special pressing construction with measuring-calibrating system which enabled insertion of a needle in further procedure.

After a shortened version of MR examination in 3D T1 DYN sequence after intravenous contrast agent administration (Multihance, dose-0,1 ml/kg of body mass), imaging data were transferred to DYNACAD diagnostic station for calibration and localization of the suspected lesion with automatic calculation of the parameters for insertion. For biopsy, we used needles with diameter of 14G with automatic biopsy gun.

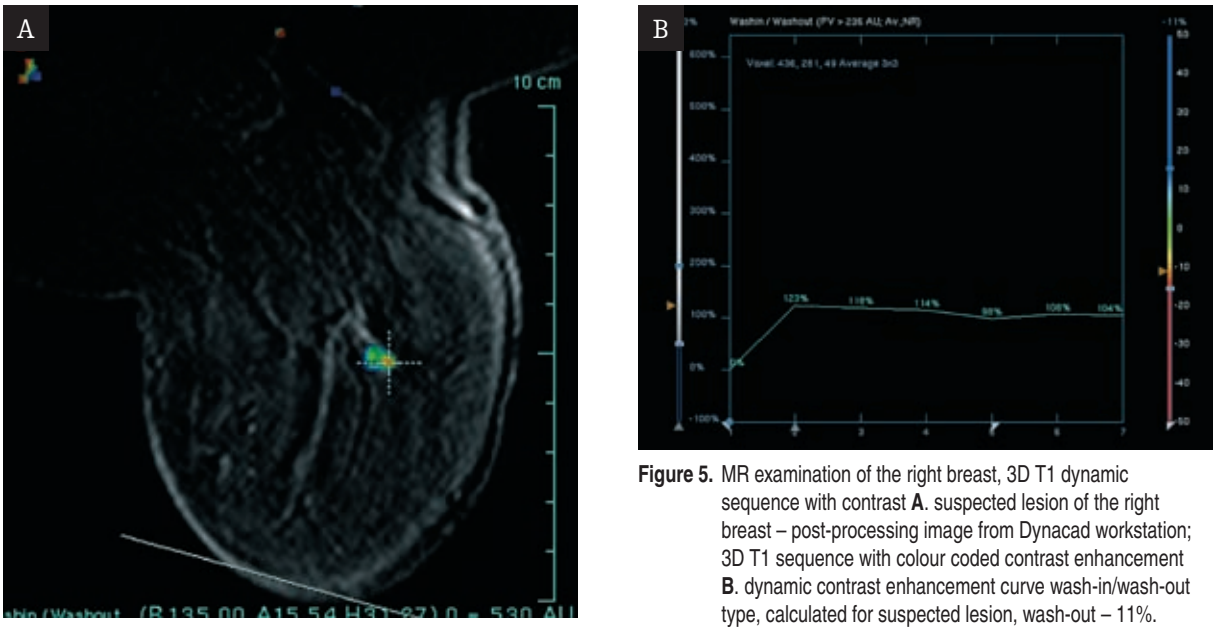


Figure 5. MR examination of the right breast, 3D T1 dynamic sequence with contrast **A**. suspected lesion of the right breast – post-processing image from Dynacad workstation; 3D T1 sequence with colour coded contrast enhancement **B**. dynamic contrast enhancement curve wash-in/wash-out type, calculated for suspected lesion, wash-out – 11%.

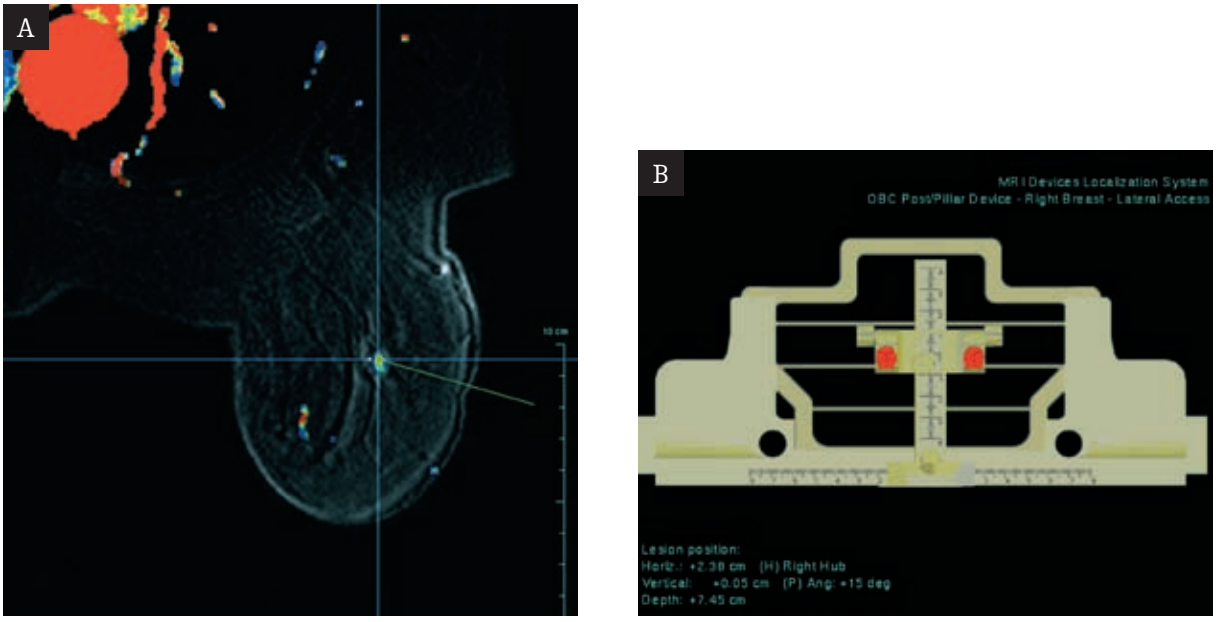


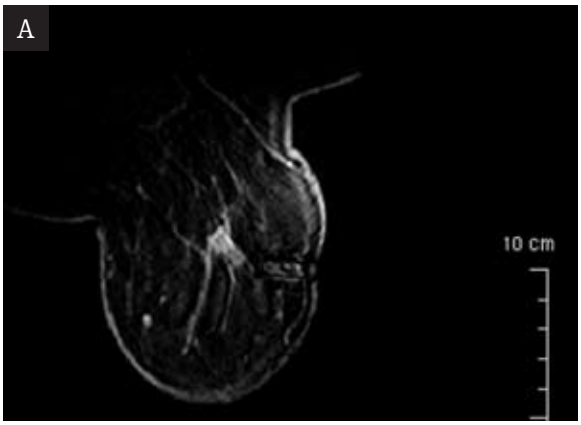
Figure 6. Pre-biopsy localization procedure **A**. suspected lesion of the right breast – post-processing image from Dynacad workstation, 3D T1 sequence with colour coded contrast enhancement; marking the lesion with blue cross results in automatic calculation of biopsy target parameters, green line showing the distance the needle needs to cover to get to the target **B**. Schema of the immobilization and biopsy positioning device with already adjust position to biopsy, based on the calculated target parameters (left, lower corner of the image).

The patients were always informed that every move of their body can result in failure of the procedure due to dislocation of the lesion from to the previously calculated parameters. Before the needle insertion the site was injected with 1% lignocaine. In total, 5 samples were collected as the needle position was changed (clock hours were the reference points) from 12 o'clock, through 3, 6, 9 to 12 once again. Marker was not put on the biopsy site.

The procedure was performed with the table set on the so-called „home" position, in which the patient is maximally moved away from the inside of permanent magnet but the system can still record the data from localization sequences. It ensured the possibility to quickly repeat the control sequence (depending on the needs it can be during or right after the biopsy) without the necessity of repeating the localization sequences, in other words preserving the continuity of a single MR examination (fig. 3-11).

After the procedure pressure dressing was applied with an elastic bandage.

The material was put in 10% formalin and sent to histopathologic examination to the Chair of Pathomorphology CM, Jagiellonian University.



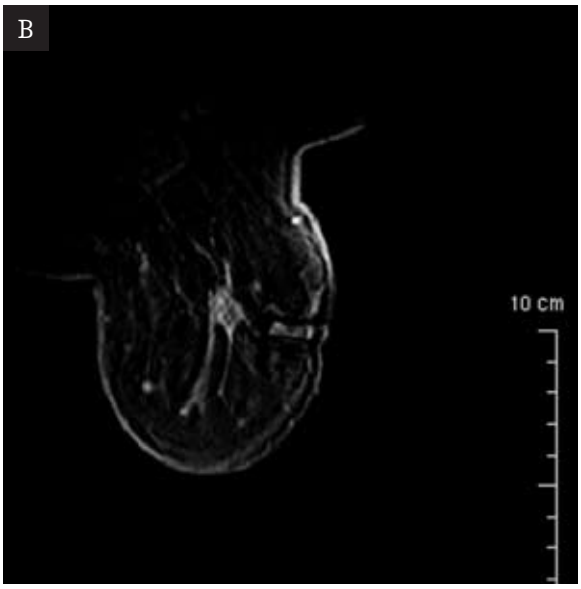
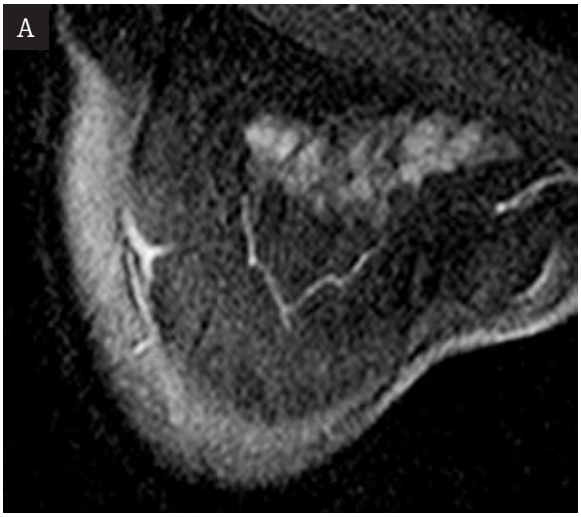
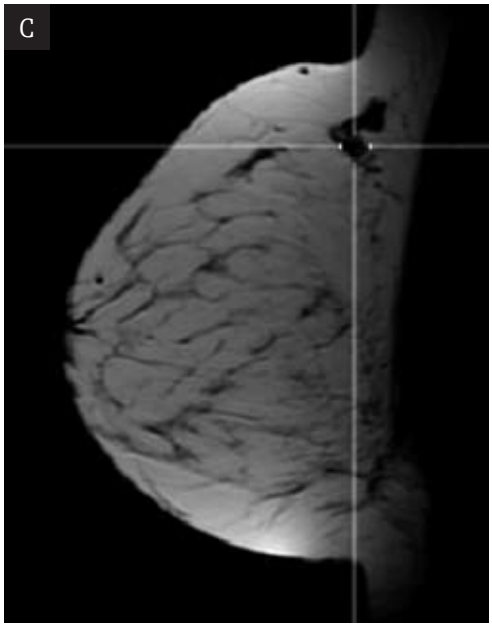


Figure 7. Control images of the breast during and after biopsy **A**. suspected lesion in dynamic 3D T1 FS sequence before biopsy, with biopsy needle right in front of the lesion, after releasing the spring-loaded needle it moves forward 1 cm hitting the lesion. **B**. suspected lesion in dynamic 3D T1 sequence just after biopsy; part of the lesion disappears.





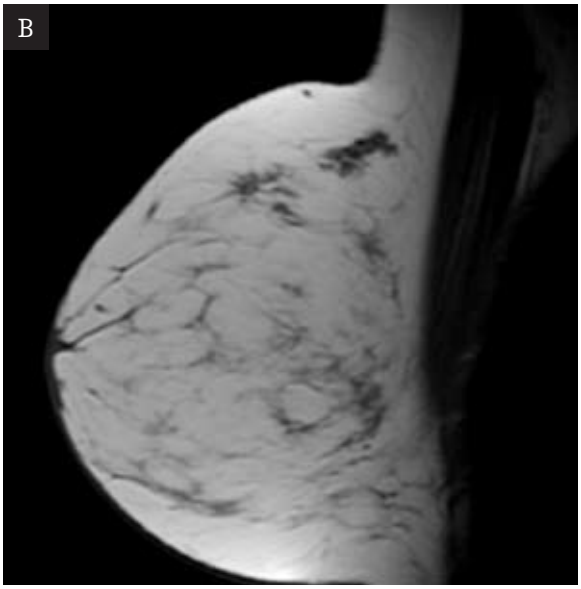


Figure 8. MR examination of the left breast **A**. image of the left breast in dynamic 3D T1 sequence with contrast infusion, axial plane **B**. image of the left breast in FSE T2 sequence, sagittal plane **C**. image of the left breast in FSE T2 sequence with suspected lesion marked with blue cross, sagittal plane.

Results

Twelve women were referred to MR-guided biopsy.

In one woman after dynamic MR of breast performed in order to localize the lesion, no signal enhancement was observed around the lesion qualified for biopsy based on the previous diagnostic MR of breast. The next MR carried out instantly, this time without pressure, did not show the lesion described in the previous MR exam either. As the lesion was neither visualized in MR performed 6 months later, it was considered to be an artifact.

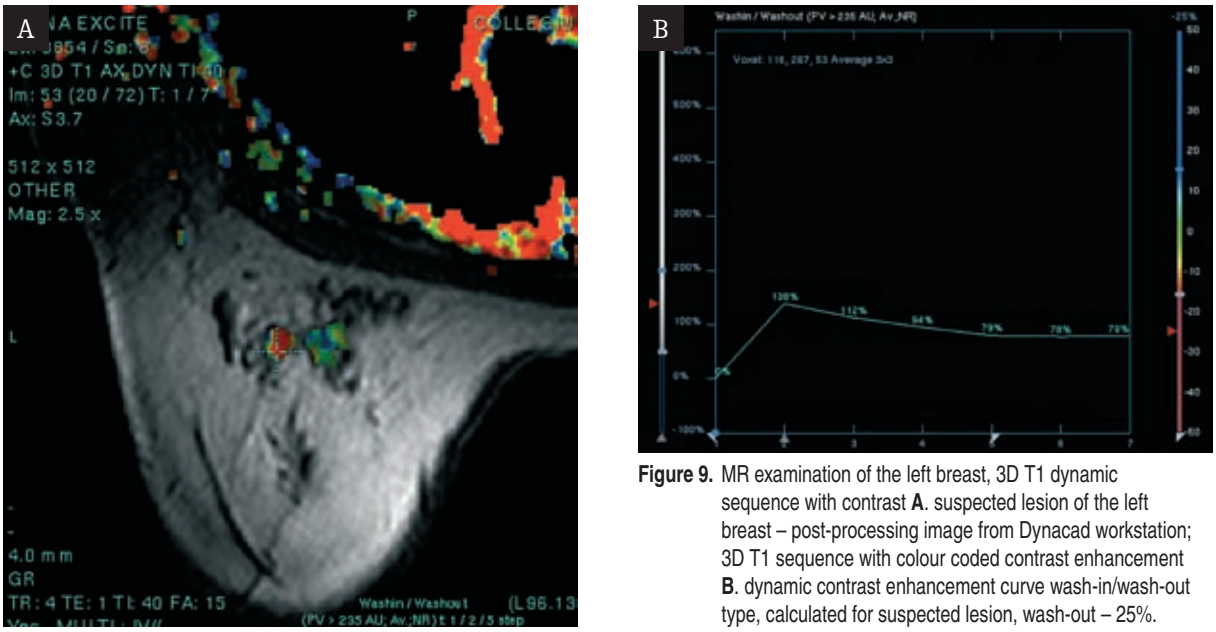


Figure 9. MR examination of the left breast, 3D T1 dynamic sequence with contrast **A**. suspected lesion of the left breast – post-processing image from Dynacad workstation; 3D T1 sequence with colour coded contrast enhancement **B**. dynamic contrast enhancement curve wash-in/wash-out type, calculated for suspected lesion, wash-out – 25%.

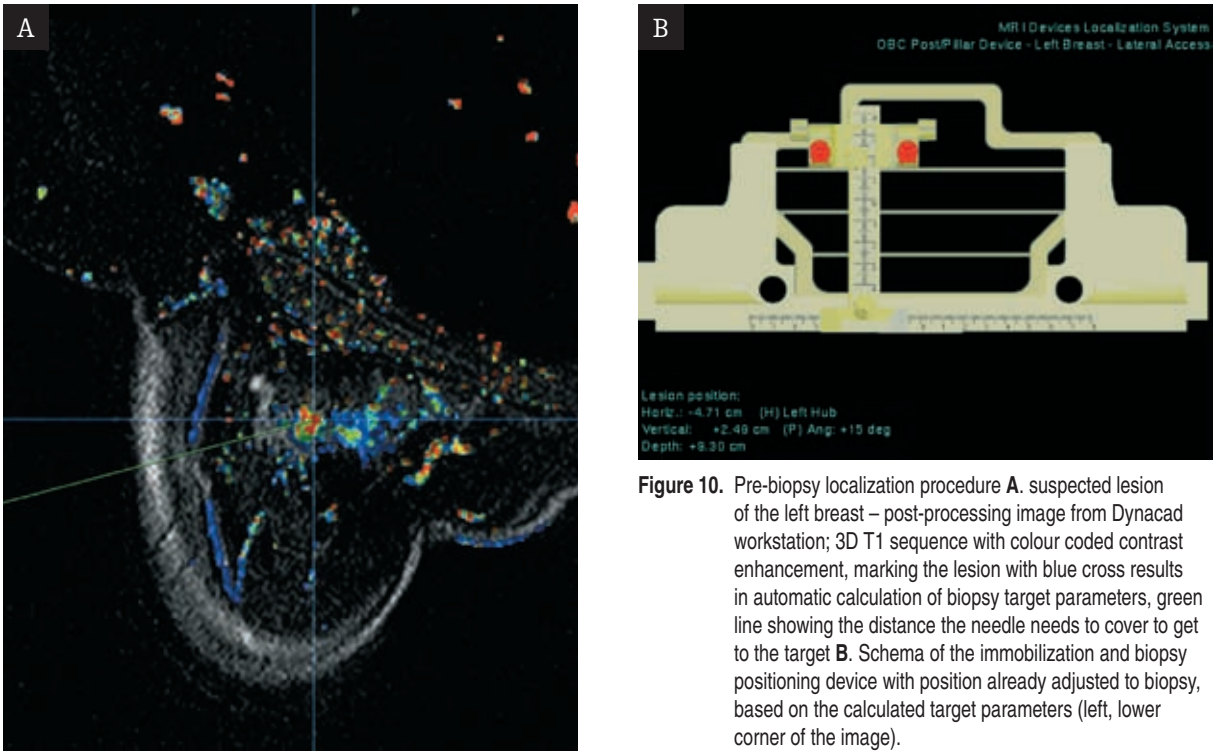
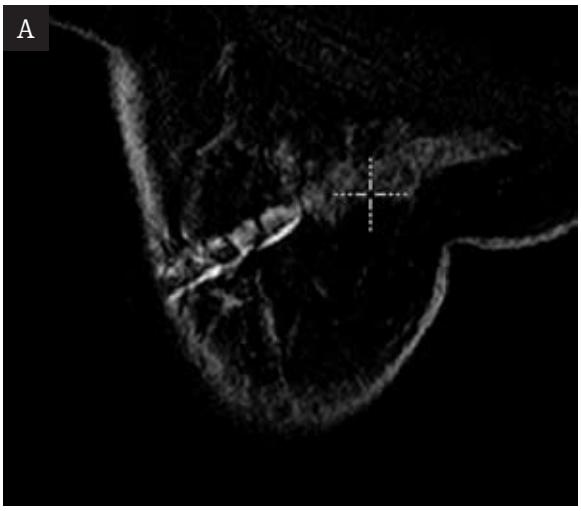


Figure 10. Pre-biopsy localization procedure **A**. suspected lesion of the left breast – post-processing image from Dynacad workstation; 3D T1 sequence with colour coded contrast enhancement, marking the lesion with blue cross results in automatic calculation of biopsy target parameters, green line showing the distance the needle needs to cover to get to the target **B**. Schema of the immobilization and biopsy positioning device with position already adjusted to biopsy, based on the calculated target parameters (left, lower corner of the image).

In 2 women the lesion qualified for biopsy was located in the upper inner quadrant, close to the thoracic wall- beyond the reach of biopsy needle. In follow-up MR of breast repeated after 6 months the image of described areas remained unchanged. Due to the fact that they were initially qualified to group III according to BIRADS, the following MR was scheduled to be performed in 6 months time and systematic conventional imaging examinations were recommended as well.

In all 9 women who underwent the procedure the obtained material was sufficient for histopathologic investigation. In 3 cases neoplastic lesions were revealed – 1 ductal carcinoma, 1 lobular carcinoma, 1 lobular carcinoma in situ (LCIS), in 2 patients- intraductal papilloma, in 1– intraductal hyperplasia without atypia and in the remaining 3 – benign degenerative fibrocystic lesions.

None of the patients suffered from side effects. In 3 of them mild livid coloration appeared on skin but disappeared spontaneously. Follow-up US examinations carried out 7 days later showed nothing more than a little distortion of tissue at biopsy site.



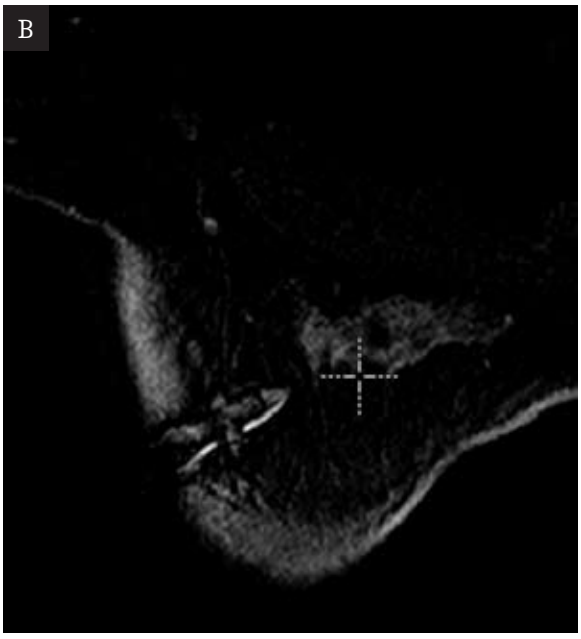


Figure 11. Control images of the breast during and after biopsy **A**. suspected lesion in dynamic 3D T1 sequence before biopsy, with biopsy needle just in front of the lesion, after releasing the spring-loaded needle it moves forward 1 cm hitting the lesion. **B**. suspected lesion in dynamic 3D T1 sequence just after biopsy, part of the lesion disappears.

Patients with neoplastic lesions in breasts were referred to surgical procedures. In 2 cases postsurgical histopathologic examinations confirmed the biopsy findings and in 1 case the biopsy diagnosis was changed (based on postoperative finding) from LCIS to invasive lobular carcinoma. For the results- see Table 3.

Discussion

Open surgical biopsies or US and mammography-guided core biopsies are the most commonly applied procedures as they can verify the character of nonpalpable lesions. Relative simplicity and possibility of its fast performance explains why they are preferred in all cases where it is possible to visualize suspected lesions using the aforementioned methods. Indeed, in 12 cases that we studied presentation of the suspected lesions in MR examination enabled visualization of the lesions in repeated conventional exams and then performance of biopsy with guidance of the aforementioned techniques.

At the same time the MR examination of breast becomes more and more popular and visualization of lesions undetectable in other imaging examinations has become the reason for introduction of similar verifying methods performed with MR guidance.

The method first developed was the MR-guided insertion of localization needles with a following open surgical biopsy. Considering the logistics (significant distance from operating suite, necessity to precisely coordinate the work at MR laboratory with surgical team, etc.) and no possibility of follow-up MR examination of the resected sample to investigate the completion of procedure led to the introduction of percutaneous systems for MR-guided core biopsies [5].

Table 3. Number, localization, morphology and comparison of histopathologic post-biopsy results (MR guided) with histopathology after surgical excision.

Patient No.	Lesion localization	Dimensions	Group according to BIRADS	Post-biopsy histopathology	Postsurgical histopathology
1.	RB, marginal outer qw.	8x10 mm	III	Fibroadipose tissue. in lymph gland, (mild dysplasia)	Not performed
2.	RB, marginal upper qw.	8x10 mm	V	Ca lobulare; ADH	Ca lobulare; Ca ductale
3.	LB, upper inner qw.	10x5 mm	III	Fibrous tissue (mild dysplasia)	Not performed
4.	RB, lower outer qw.	6x7 mm	III	Fibroadipose tissue (mild dysplasia)	Not performed
5.	LB, lower outer qw	7x10 mm	IV	ca ductale	ca ductale
6.	RB, marginal outer qw.	10x6 mm	IV	Fibrous tissue, dilatated lactiferous duct (mild dysplasia)	Not performed
7.	RB, upper outer qw.	8x6 mm	IV	LCIS	LCIS, ca lobulare
8.	RB, margin of outer qw.	11x10 mm	IV	papillomatosis intraductalis	Not performed
9.	LB, upper outer qw.	7x8 mm	IV	NADH	Not performed

However, problems and limitations occurred right away. The necessity to have biopsy attachment, software and special open mammographic coil which gives access to the examined breast with no need to move the patient outside the magnetic field during procedure, became fundamental. It was also complicated by the fact that the exams had to be performed with high-field devices (≥1T) of closed construction what hindered the access to the examined breast. The only reasonable solution was pulling out the table with patient (after pre-biopsy sequences) to the so-called "home" position [6, 7]. The duration of diagnostic MR mammography is up to 30-40 minutes. Moreover, it takes 10-20 minutes to process the examination on diagnostic console. The times are similar to those mentioned in literature [8].

To maximally limit the time when a patient needs to remain still, in our institute the diagnostic MR of breast was excluded in biopsy procedure. It increased the cost of examination – the localization requires additional dynamic examination after contrast agent administration prior to biopsy – but the patient's comfort and chance of proper insertion of biopsy needle (due to minimization of biopsy time) has improved greatly. The whole procedure takes less than 20 minutes from placing the patient on the table to the control sequence after biopsy.

Another limitation of the procedure, mentioned by radiologists performing MR-guided biopsy, was the use of open mammographic coil (also in our institute) which allowed performing a biopsy only from the lateral access [2, 8]. Therefore, for us it was impossible to perform biopsy in 2 patients in whom the lesions were located near the thorax, in upper inner quadrants. Better option, preferred by most authors, is to use coils which enable to set the compression- calibration system after pulling the other breast up and allow performance of the biopsy in the inner quadrants as well. Unfortunately, such coil is much more expensive.

Similar difficulties occur when lesions are located in outer quadrants and close to the thoracic wall. The access to them is blocked by the upper edge of pressing construction. The problem can sometimes be solved by strongly pushing the breast into the hole in the coil, thus automatically moving the lesion away from its edge.

In the presented group there was also a case no contrast enhancement of the focal lesion during the pre-biopsy dynamic sequence. In literature it is estimated for 10 % of cases and it is explained by performing the first MR exam in a wrong period of the menstrual cycle (not between 5-17th day of the cycle) or by taking oral hormone substitutive therapy (HRT) [3]. For our patients we scheduled the examination according to the day of menstrual cycle and we always asked if they took HST. In literature the lack of enhancement is sometimes associated with stronger compression of breasts what can lead to difficulties in contrast blood supply to the lesion [9]. In our case it was excluded in the following MR examinations of breast which did not reveal the previously described lesion and allowed us to qualify it to the group of artifacts.

We need to agree with authors who emphasize that a reliable control during and after the biopsy can be difficult due to occurrence of artifacts in MR images which are associated with the presence of either needle or extravasated blood [8, 9, 10]. The obtained results suggest the necessity to compare results obtained from histopathologic examination after biopsy with pre-biopsy BIRADS category of the verified lesion. Although the histopathologic result suggesting benign lesion for a focus qualified to BIRADS 3 seems to confirm the diagnosis, similar results for a lesion qualified to BIRADS 4 or 5 should induce to consider tumorectomy.

Undoubtedly, the factor that influences the reliability of histopathologic results is the volume of tissue collected during biopsy, i.e. the type of applied needle. Most examinations seem to confirm that the best results are acquired from vacuum assisted core biopsy [2, 8, 9]; however, high cost of the appropriate equipment, as well as the needle itself, limit the access to this procedure in Poland.

In our laboratory we perform biopsy using needles with diameter of 14G, with automatic biopsy gun.

The obtained results -3 neoplasms in 9 biopsies- suggest that despite the difficulties (concerning mainly own experience which needs to be gained when a new method is introduced) such procedure should be applied more often in patients in whom the presence of focal lesion was only found in MR of breast. One should not forget that approx. 90% of such lesions are benign and therefore the use of open surgical biopsy- an alternative for MR biopsy- is an unnecessary mutilation to the patient.

Conclusions

1. Suspected focal lesion revealed by MR examination and visible in second-look US or mammography should be biopsed with guidance of one of these two last methods.

2. All nonpalpable lesions found only in MR examination (which show contrast signal enhancement in dynamic examination) should be verified with percutaneous MR-guided biopsy.

3. MR-guided biopsy should not be performed on the same day as diagnostic MR of breast.

4. The most universal coils are those which allow biopsy also from the medial access.

5. The breast should not be compressed too strongly but well stabilized in order to avoid difficulties in blood supply; it reduces the risk of no supply in contrast blood.

6. Mild histopathologic result should always be carefully compared with pre-biopsy assessment – the BIRADS classification.

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