Abbreviated MRI Protocols: Efficacy in Improving Acquisition and Interpretation Time in Breast Cancer

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ABSTRACT

Background: To be cost-effective, the abbreviated magnetic resonance imaging (MRI) protocols have to be proved to reduce examination and reading times, while being clinically effective.

Objective: To investigate the efficacy of these protocols in enhancing the efficiency of exams and reducing interpretation time. The study reviews the rationale behind abbreviated protocols and why they are an essential evolving tool in breast screening programs. **Patients and methods:** This was a prospective randomized study. 60 female patients were examined. They were presented to Kasr Al-Ainy Medical School Breast Unit for screening. Patients were stratified using a risk assessment model. Different risk categories were included. **Results:** Abbreviated MRI is proved to be a cost-effective method of screening for breast cancer. It has found to be faster to be performed compared with traditional mammogram, as given all the preparation required and proper position needed in mammograms, MRI would be a better modality. Average time for completing abbreviated MRI (AB-MRI) was 5.1 minutes, while mammograms took 10 min. Reading AB-MR took an average of 4.7 minutes, while traditional mammograms 5.7minutes. Regarding efficacy, when compared to traditional screening methods, AB-MR showed the following: 100% negative predictive value (NPV), 85.7% specificity, 50% positive predictive value (PPV), and 100% sensitivity in breast cancer. **Conclusion:** Abbreviated MRI was found to be an efficient method to identify breast cancer, with shorter imaging and reading times.

Keywords: Time-efficacy, abbreviated MRI, AB-MR, breast cancer.

INTRODUCTION

Different tools are currently used to assess patent's risk of breast cancer [(1)].

As it is essential for all women to have a screening test, we are continuously looking for affordable and efficient ways to achieve that [(2)]. MRI has been proved to be an excellent modality for this purpose. However, it is a costly method, due to the long protocol used and the expertise needed for interpreting these scans [(3)]. The most cost-effective technique for screening for breast cancer is mammography [(4)]. However, MRI has been proved to be a better modality, especially in women with dense breast composition [(5)]. Mammograms of women with dense breasts are more likely to miss malignancies [(6)]. Furthermore, screening women who are at high risk of breast cancer with mammography alone is inadequate [(7)]. Hence, abbreviated protocols were developed, in an attempt to develop a less expensive and more efficient tool for assessing breast cancer [(8)]. Breast MRI screening has best results in women with a family or personal history of breast cancer, particularly in those who have had breast conservation surgery [(9, 10)]. While there are many advantages to magnetic resonance imaging (MRI) for screening and surveillance, its use is limited because of its high cost, restricted availability, requirement for injecting contrast media for sufficient imaging, and lack of standardisation in terms of technique and interpretation criteria for breast MRIs [(11)].

In this study, the time of acquisition as well as interpretation of one of the formulated abbreviated protocols has been assessed and calculated. If proved efficient and less time consuming than traditional screening tests, this could be used instead of morphological characteristics of the lesions.

PATIENTS AND METHODS

This is a prospective randomized study. 60 female patients were examined. They were presented to Kasr Al-Ainy Medical School Breast Unit for screening between November 2019 and September 2020. Patients were stratified using a risk assessment model. Different risk categories were included.

Data collection: Mammography and tomosynthesis (Amulet Innovality, Fujifilm global, Bellus black and white workstation, 5 megapixels) were used for initial patient's assessment. In a few patients, ultrasound could have been used as an additional assessment. MRI machine used was (1.5 Tesla Philips MRI scanner, phased-array breast coil).

Acquisition times were recorded for both modalities. Both modalities were then read by a senior registrar and a consultant breast radiologist, with 10 years of experience in breast imaging. Reading times for both modalities were also collected.

MR protocol: MRI machine used was (1.5 Tesla Philips MRI scanners, with an 8- channel dedicated phased-array breast coil).

MRI protocols used comprise the following: Unenhanced non-fat-saturated T1- weighted images, first contrast enhanced fat saturated T1 weighted images, subtracted first contrast enhanced fat saturated T1 weighted images, MIP images. Contrast was injected using a high-pressure syringe. Data were processed.

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Acquisition time was recorded for each patient (time of the MR examination only).

The cases included were patients with intermediate and high-risk of breast cancer (women with family history of breast cancer, precancerous lesions, previous conservative breast surgery or contralateral mastectomy, dense breast category C and D). The women were investigated using mammography and focused ultrasound if needed, followed by Ab-MR.

Ethics approval and consent to participate: The Ethics Committee of Faculty of Medicine, Suez Canal University, reviewed and approved this research study. All patients who participated in the study verbally agreed after the procedures were explained to them. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Data Analysis: Expert breast radiologists interpreted every image. A senior breast radiologist was consulted in case of any uncertain finding. Mammogram/ultrasound and abbreviated MR protocol were interpreted separately, and a conclusion was obtained for each. Interpretation time was obtained for each patient. The time taken for diagnosis and the diagnosis reached based on the BI-RADS was also recorded. All parameters were calculated.

Data Management and statistical analysis: Collected data were processed using IBM SPSS version 20.0 (SPSS Inc., Chicago IL, USA). Quantitative data was expressed as a mean +_SD. The McNemar's test was used to assess the sensitivity and specificity.

RESULTS

Table 1: Distribution of the studied cases according to age (n=60)

Age (years)	No.	%
≤50 >50	24 36	40.0 60.0
Min. – Max. Mean ±SD. Median	40.0 – 80.0 56.12 ± 11.04 54.50 (48.0 – 65.0)	

SD= standard deviation.

The table shows the average age of the women included in the study was 56-year-old.

Table 2: Relation between mammography-ultrasound and abbreviated MRI in cases in detection of breast cancer.

Abbreviated MRI	Mammography-ultrasound				Sensitivity	Specificity	PPV	NPV
	Negative(n= 57)		Positive(n= 3)					
	No.	%	No.	%				
Negative	55	96.6	0	0.0				
Positive	2	3.5	3	100.0	100.0	96.5	60.0	100.0
p	(<0.001)							

PPV: Positive predictive value, **NPV**: Negative predictive value

The table shows the sensitivity was (100%), specificity (96.5%), PPV (60%) and NPV (100%) of AB-MRI compared to mammography.

Table 4: Comparison between mammography-ultrasound and abbreviated MRI according to reading time.

Reading time	Mammography-ultrasound	Abbreviated MRI	p
Min. – Max.	2.0 – 13.0	2.0 – 10.0	
Median (IQR)	5.0(4.0 – 7.0)	4.0(3.0 – 5.0)	<0.001*

*: Statistically significant

The table shows a statistically significant difference in the reading time between mammography and abbreviated MR protocol (only the time of reading a targeted ultrasound if needed was added to the total mammography-ultrasound reading time).

Table 5 Comparison of acquisition time between abbreviated MR and mammography.

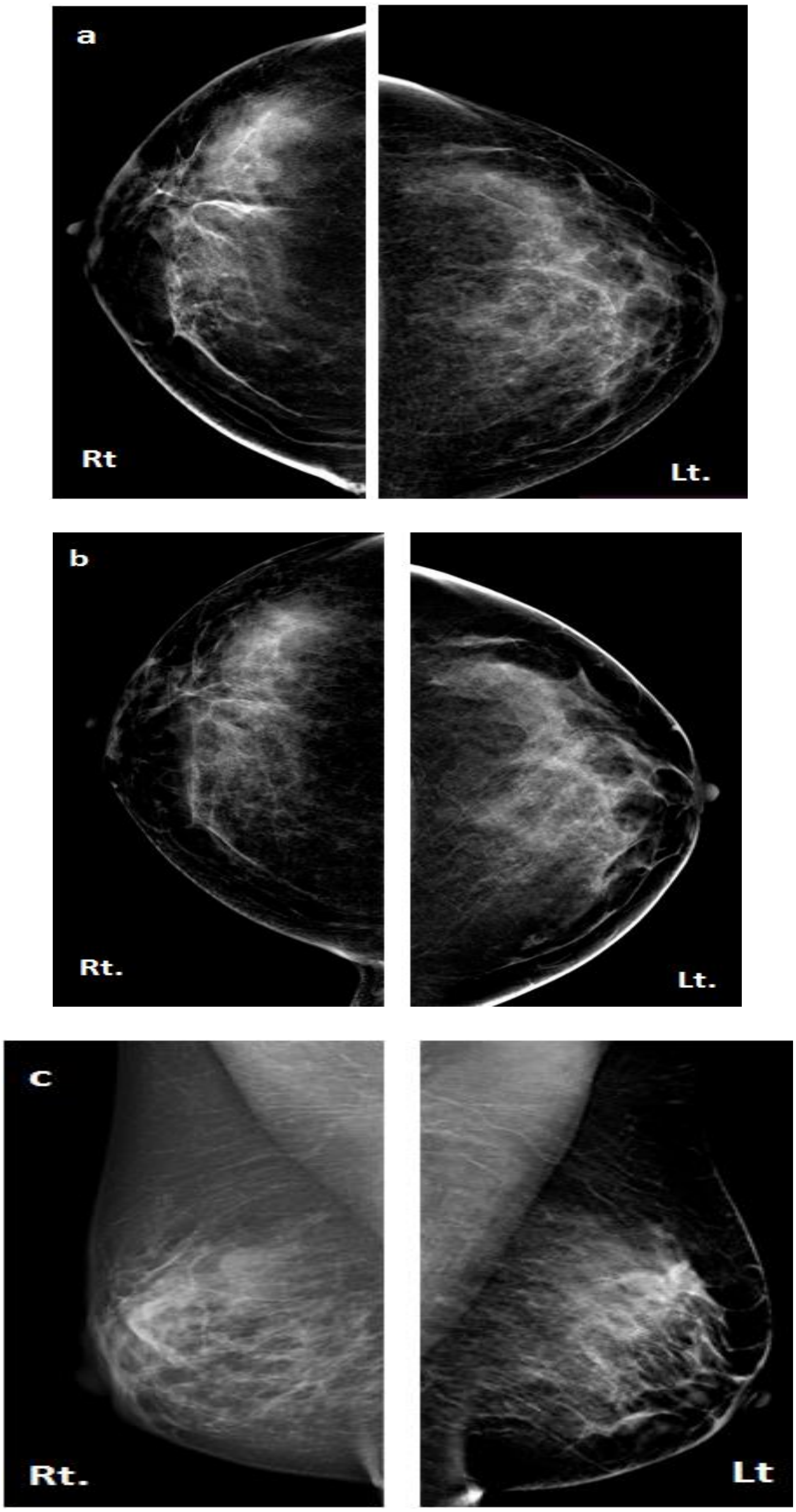
Acquisition time	Abbreviated MR	Mammography	p
Min. – Max.	2.0 – 8.0	7.0 – 15.0	
Median (IQR)	5.0(4.0 – 6.0)	10.0(9.0 – 11.0)	<0.001*

*: Statistically significant

The table shows that the mean time of acquisition for mammography was significantly longer compared to abbreviated MR.

CASES

Figure 1: (A) 50-year-old patient with previous history of surgical excision of aprecancerous lesion (radial scar) 2 years ago



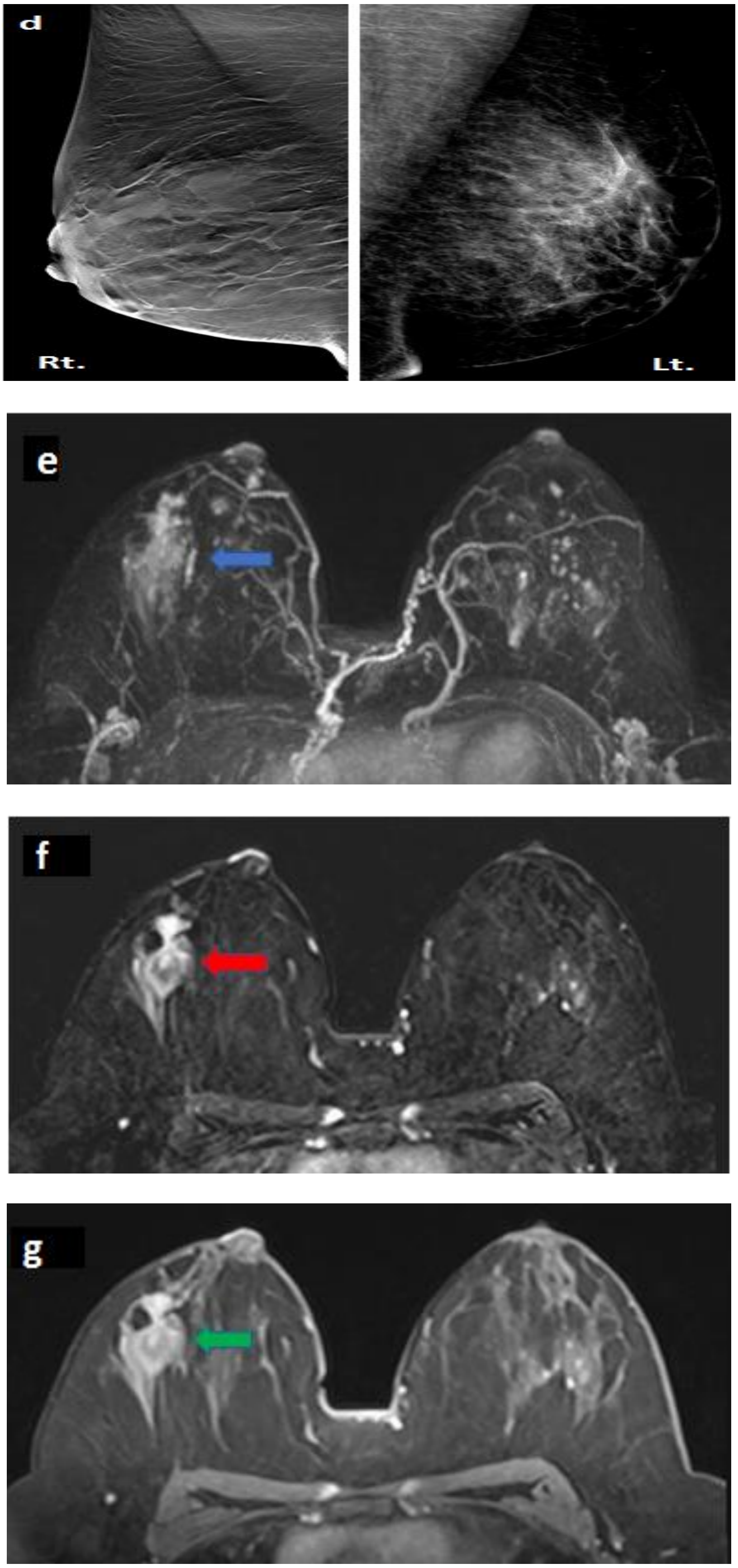


Figure (1): (a) Rt. and Lt. CC mammogram. **(b)** Rt. and Lt. MLO mammogram. **(c)** Rt. and Lt. CC tomosynthesis. **(d)** Rt. and Lt MLO tomosynthesis. No suspicious masses or calcifications could be detected in the four images. **(e)** MIP post-contrast image shows a segmental non-mass enhancement (NME) in the right breast (blue arrow). **(f)** T1 fat-suppression post-contrast subtracted image demonstrating the non-mass enhancement with heterogenous post-contrast enhancement (red arrow). **(g)** T1 fat- suppression post-contrast image also clearly shows the NME (green arrow). According to the MR findings, the lesion was assigned BI-RADS 4C and a biopsy was performed. The tissue biopsy revealed a ductal carcinoma in situ (DCIS).

Figure 2. A 61-year-old lady with history of lumpectomy 12 months ago presented for screening.

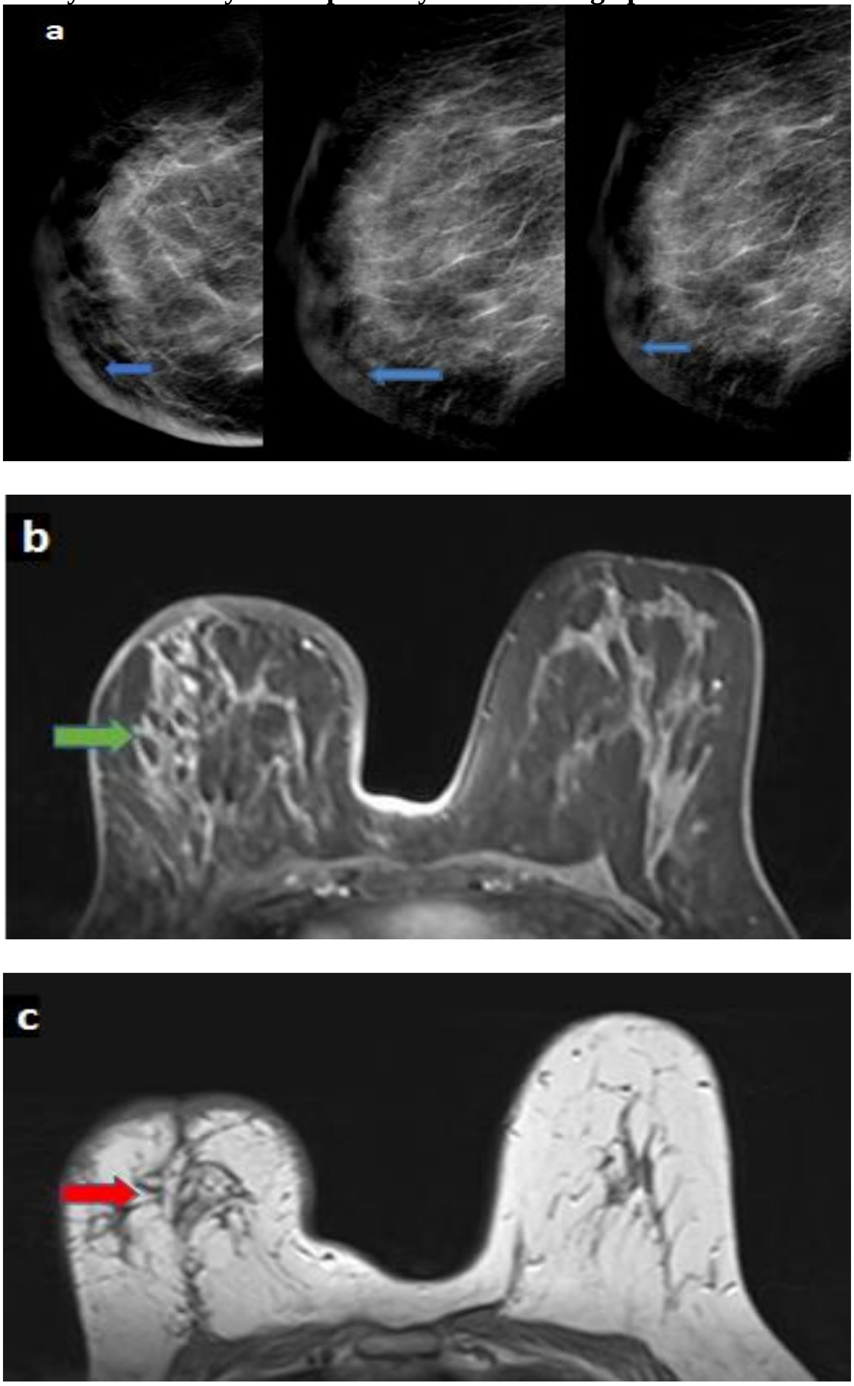


Figure (2): (a) RT CC and MLO tomosynthesis showing different slices demonstrating post-operative skin thickening (blue arrow). No other lesions could be detected. **(b)** Shows T1 fat- suppressed first post contrast image showing a hypointense lesion with no contrast enhancement (green arrow). The skin thickening could also be appreciated. **(c)** T1 with no fat suppression shows that the previously seen lesion has fat signal (red arrow). The lesion was diagnosed as fat necrosis (BI-RADS 2).

DISCUSSION

No screening method was shown to have a high level of specificity and sensitivity in every patient [7]. The current study showed that, when compared to established diagnostic procedures, the shortened MR protocol had improved sensitivity, specificity, PPV, and NPV for the detection of breast cancer in women. Mammography and ultrasound were not able to correctly identify all the cancers later proved by biopsy; by contrast, Ab-MRI correctly identified all of them. When Ab-MRI was contrasted with mammography and ultrasounds, the results for sensitivity, specificity, PPV, and NPV were higher.

However, to accept abbreviated MRI as a screening tool, the evaluation of acquisition time is crucial in determining if an AB-MR procedure is feasible. It was observed that the acquisition time for this protocol was significantly lesser ($p<0.001$) than that of the mammography and ultrasound (average 5.1 minutes for MRI and 10 minutes for mammography and ultrasound] + 1.98 min and 4.98 + 1.30 min, respectively). This might be due to the challenges imposed while trying to perfect mammography and ultrasound acquisition, especially in women with larger breasts.

Another crucial factor to consider was reading time for both modalities. According to reports, quicker interpretation times for MRI protocols were seen than for mammograms [12]. Between two and ten minutes were needed on average to understand the current shortened protocol (mean = min 4.6 ± 178 SD). In comparison to mammogram and ultrasonography, this was shown to be significantly lower ($p<0.001$). Additionally, interpretation of the images happened faster than with complete MRI protocols. The average time taken to interpret the entire protocol was 6.43 minutes by **Monticciolo *et al*.** [13] and 6 minutes by **Nathaniel *et al*.** [14]. **Kuhl *et al.*** [14] however, reported their entire technique in a mere 2.95 minutes [15]. This is less than the interpretation time of the current study. To address the cause of higher reading times in this study compared to other studies, it is believed that the study's longer reading duration is due to the fewer sequences that were offered. The absence of a well-known dynamic curve was also crucial. Also, to be noted the abnormalities were quickly identified. This additional time was spent on trying to characterize the lesion seen and not the identification itself.

There were certain restrictions on our investigation. One of the disadvantages is that readers may not be accustomed with the shortened protocol, which could result in a lengthier interpretation time in some situations. Nonetheless, most patients' AB-MRI reports were reported without any issues by the reader. Additionally, since fewer sequences are needed to generate higher results than the entire technique, less reader training is needed. Future research should be carried on to further reduce acquisition time for AB-MR. Furthermore, readers would benefit from training to decrease reading time.

CONCLUSION

Abbreviated MRI protocols demonstrate significant potential in improving exam and interpretation times without compromising diagnostic accuracy. As technology continues to evolve, these protocols may play a pivotal role in enhancing the efficiency and accessibility of MRI in clinical practice, ultimately benefiting both patients and healthcare providers. Further research and standardization efforts are essential to validate and establish the widespread adoption of abbreviated MRI protocols.

DECLARATIONS

- **Consent for publication**: The final draft for publication was approved by all authors.
- **Availability of data and material:** The datasets used and analyzed in this study are available from the corresponding author upon reasonable request.
- **Conflicts of Interest:** The authors declare no conflicts of interest regarding the publication of this paper.
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