Abbreviated Versus Full-Protocol MRI for Breast Cancer Neoadjuvant Chemotherapy Response Assessment: Diagnostic Performance by General and Breast Radiologists

Wen-Jie Tang, MD[1], Si-Yi Chen, BS[1], Wen-Ke Hu, BS[1], Xue-Li Li, BS[1], Bing-Jie Zheng, MS[2], Zhen-Sui Wang, BS[1], Han-Jun Ding, BS[1], Lei-Xin Chen, BS[1], Qiong-Qiong Zhang, BS[1], Xiao-Meng Yu, BS[1], Yi Sui, BS[1], Xin-Hua Wei, MD, PhD[1], Yuan Guo, MD, PhD[1]

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W. J. Tang, S. Y. Chen, and W. K. Hu contributed equally to this work.

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BACKGROUND. Abbreviated protocols could allow wider adoption of MRI in patients undergoing breast cancer neoadjuvant chemotherapy (NAC). However, abbreviated MRI has been explored primarily in screening settings.

OBJECTIVE. The purpose of this article was to compare diagnostic performance of abbreviated MRI and full-protocol MRI for evaluation of breast cancer NAC response, stratifying by radiologists' breast imaging expertise.

METHODS. This retrospective study included 203 patients with breast cancer (mean age, 52.1 ± 11.2 [SD] years) from two hospitals who underwent MRI before NAC initiation and after NAC completion before surgical resection from March 2017 to April 2021. Abbreviated MRI was extracted from full-protocol MRI and included the axial T2-weighted sequence and precontrast and single early postcontrast T1-weighted sequences. Three general radiologists and three breast radiologists independently interpreted abbreviated and full-protocol MRI in separate sessions, identifying enhancing lesions to indicate residual tumor and measuring lesion size. The reference standard was presence and size of residual tumor on pathologic assessment of post-NAC surgical specimens.

RESULTS. A total of 50 of 203 patients had pathologic complete response (pCR). Intraobserver and interobserver agreement for abbreviated and full-protocol MRI for general and breast radiologists ranged from substantial to nearly perfect (κ = 0.70–0.81). Abbreviated MRI compared with full-protocol MRI showed no significant difference for general radiologists in sensitivity (54.7% vs 57.3%, $p > .99$), specificity (92.8% vs 95.6%, $p = .29$), or accuracy (83.4% vs 86.2%, $p = .30$), nor for breast radiologists in sensitivity (60.0% vs 61.3%, $p > .99$), specificity (94.6% vs 97.4%, $p = .22$), or accuracy (86.0% vs 88.5%, $p = .30$). Sensitivity, specificity, and accuracy were not significantly different between protocols for any reader individually ($p > .05$). Mean difference in residual tumor size on MRI relative to pathology for abbreviated protocol ranged for general radiologists from −0.19 to 0.03 mm and for breast radiologists from −0.15 to −0.05 mm, and for full protocol ranged for general radiologists from 0.57 to 0.65 mm and for breast radiologists from 0.66 to 0.79 mm.

CONCLUSION. Abbreviated compared with full-protocol MRI showed similar intraobserver and interobserver agreement and no significant difference in diagnostic performance. Full-protocol MRI but not abbreviated MRI slightly overestimated pathologic tumor sizes.

CLINICAL IMPACT. Abbreviated protocols may facilitate use of MRI for post-NAC response assessment by general and breast radiologists.

The administration of neoadjuvant chemotherapy (NAC) is becoming increasingly common in the treatment of patients with breast cancer [1–4]. However, treatment response is heterogeneous across patients, leading to a need to be able to reliably determinate NAC efficacy [5]. Breast MRI has shown utility before and after NAC to delineate disease extent and to assess treatment response and the potential for breast-conserving therapy [6–8]. However, breast MRI using a standard full protocol requires a long acquisition time, which has implications for both patient access and radiologist interpretation workload. Shortening the duration of the MRI examination, if it does not compromise diagnostic performance, may improve availability and facilitate wider application of MRI in the setting of NAC [9].

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[1]Department of Radiology, Guangzhou First People's Hospital, No 1 Panfu Rd, Guangzhou, 510180, China. Address correspondence to Y. Guo (eyguoyuan@scut.edu.cn).

[2]Department of Radiology, Henan Cancer Hospital, Affiliated Cancer Hospital of Zhengzhou University, Zhengzhou, China.

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A growing body of research, primarily performed in the screening setting, has shown abbreviated breast MRI to have comparable performance characteristics with full-protocol MRI [10–14]. In addition, in a prospective study of 1444 women with dense breasts or a history of breast cancer, screening abbreviated-protocol MRI, comprising one T2-weighted acquisition and one precontrast and one postcontrast T1-weighted acquisition, showed a higher rate of invasive breast cancer detection than digital breast tomosynthesis [11]. A paucity of literature has assessed the role of breast MRI for evaluating NAC response. In one such study, Yirgin et al. [15] observed substantial agreement between abbreviated MRI and full-protocol MRI in assessing NAC response in 50 patients, although correlation with pathologic results was slightly higher for full-protocol MRI. In their study, interpretative performance characteristics (e.g., sensitivity and specificity) were not reported. Moreover, three radiologists evaluated MRI examinations in consensus, precluding assessment of interobserver agreement or of impact of radiologist expertise in breast imaging.

The purpose of this study was to compare the diagnostic performance of abbreviated MRI and full-protocol MRI for the evaluation of NAC response in patients with breast cancer, stratifying by radiologists' level of expertise in breast imaging.

HIGHLIGHTS

Key Finding

- *Abbreviated MRI showed no significant difference from full-protocol MRI for general or breast radiologists in sensitivity (54.7% vs 57.3%; 60.0% vs 61.3%; both* p > *.99), specificity (92.8% vs 95.6%,* p = *.29; 94.6% vs 97.4%,* p = *.22), or accuracy (83.4% vs 86.2%; 86.0% vs 88.5%; both* p = *.30).*

Importance

- *Abbreviated protocols may allow wider application of MRI for assessing breast cancer treatment response, thereby helping to inform decisions regarding breast-conserving therapy.*

Methods

Study Sample

This retrospective study was approved by the ethics committee of two participating hospitals (Guangzhou First People's Hospital and Henan Cancer Hospital). The requirement for written informed patient consent was waived. For each hospital, a patient management system was searched for patients with pathologically diagnosed invasive breast cancer from March 2017 to April 2021, identifying a total of 796 patients. Patients were initially excluded for the following reasons: patient did not undergo NAC (*n* = 462), patient did not undergo MRI before NAC (*n* = 37), patient did not undergo MRI after completion of NAC (*n* = 31), or surgical resection was not performed within 10 days after the post-NAC MRI examination (*n* = 11). These exclusions resulted in 255 eligible patients. Additional patients were excluded for the following reasons: inadequate MR image quality (*n* = 18), lack of maximum-intensity-projection (MIP) images or subtraction images (*n* = 9), breast biopsy performed within 15 days before pre-NAC MRI examination (*n* = 16), and bilateral breast cancer (*n* = 9). Patients with breast biopsy before were excluded because of potential distortion of MRI findings resulting from a recent biopsy. After these additional exclusions, the final sample included 203 patients who underwent a total of 406 MRI examinations (one before and one after NAC). Of these, 162 patients were from one hospital, and 41 were from the other. Figure 1 shows the flow of patient selection.

MRI Examinations and Protocols

MRI examinations were performed on a 1.5-T system (uMR 560, United Imaging) (*n* = 162) or a 3-T system (Elition, Ingenia, Philips Healthcare) (*n* = 41). Examinations were performed with patients in the prone position, with the breasts gently immobilized. Detailed acquisition parameters are presented in Table S1 (available in the online supplement).

Full-protocol MRI—Full-protocol MRI consisted of axial, sagittal, and coronal turbo-spin echo (TSE) fat-saturated T2-weighted sequence; axial TSE T1-weighted sequence; and axial DWI. In addition, an axial 3D gradient-echo dynamic contrast-enhanced (DCE) T1-weighted sequence was obtained before contrast administration and at five postcontrast time points. MIP images and subtraction images were generated for each postcontrast time point. The total examination time was approximately 35–45 minutes, and the total image acquisition time was approximately 20 minutes.

Abbreviated MRI—Abbreviated MRI was extracted from full-protocol MRI and included the axial fat-saturated T2-weighted sequence, the axial precontrast T1-weighted sequence, and the second axial postcontrast T1-weighted sequence with its derived image sets (MIP images and subtraction images). The sequences extracted for the abbreviated protocol had a total acquisition time of approximately 6 minutes (accounting for such steps as sequence setup and shimming).

Figure 2 shows a schematic presentation of full-protocol MRI and abbreviated MRI.

MRI Interpretation

The MRI examinations were independently interpreted by six radiologists (all from Guangzhou First People's Hospital) blinded to clinical and pathologic information, including three general radiologists (W.K.H., L.X.C., and W.J.T. with 2, 3, and 7 years, respectively, of posttraining experience in general radiology) and three dedicated breast imaging radiologists (Y.G., H.J.D., and Z.S.W., with 14, 17, and 20 years, respectively, of posttraining experience in breast imaging). None of the readers had prior clinical experience in interpreting abbreviated breast MRI. However, before the start of the study, the readers received training in abbreviated breast MRI interpretation through didactic material and review of 10 cases not included in the analysis.

For all examinations from both hospitals, image sets corresponding with the abbreviated and full protocols were initially exported in DICOM format from the clinical PACS and subsequently imported as distinct examinations into DICOM viewer software (RadiAnt DICOM viewer, version 2020.2.3). The radiologists then reviewed examinations in four sessions using the DICOM viewer software. The abbreviated examinations were reviewed in the first two sessions, and the full-protocol examinations were reviewed in the last two sessions. The first and second sessions, as well as the third and fourth sessions, were separate by 1 month;

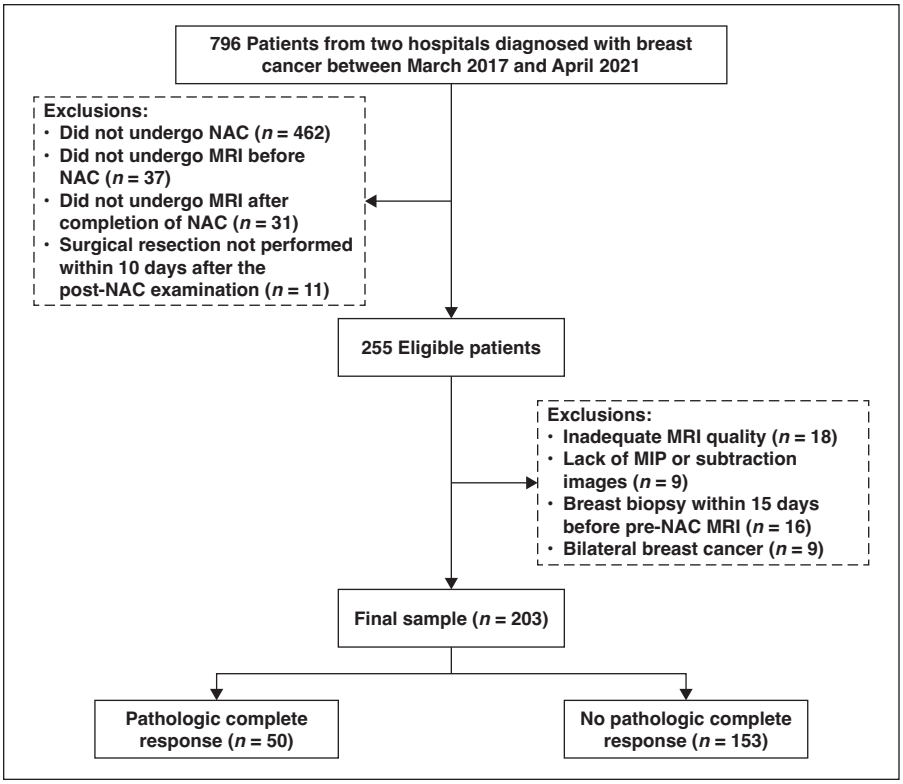

Fig. 1—Chart shows flow of patient selection. NAC = neoadjuvant chemotherapy, MIP = maximum intensity projection.

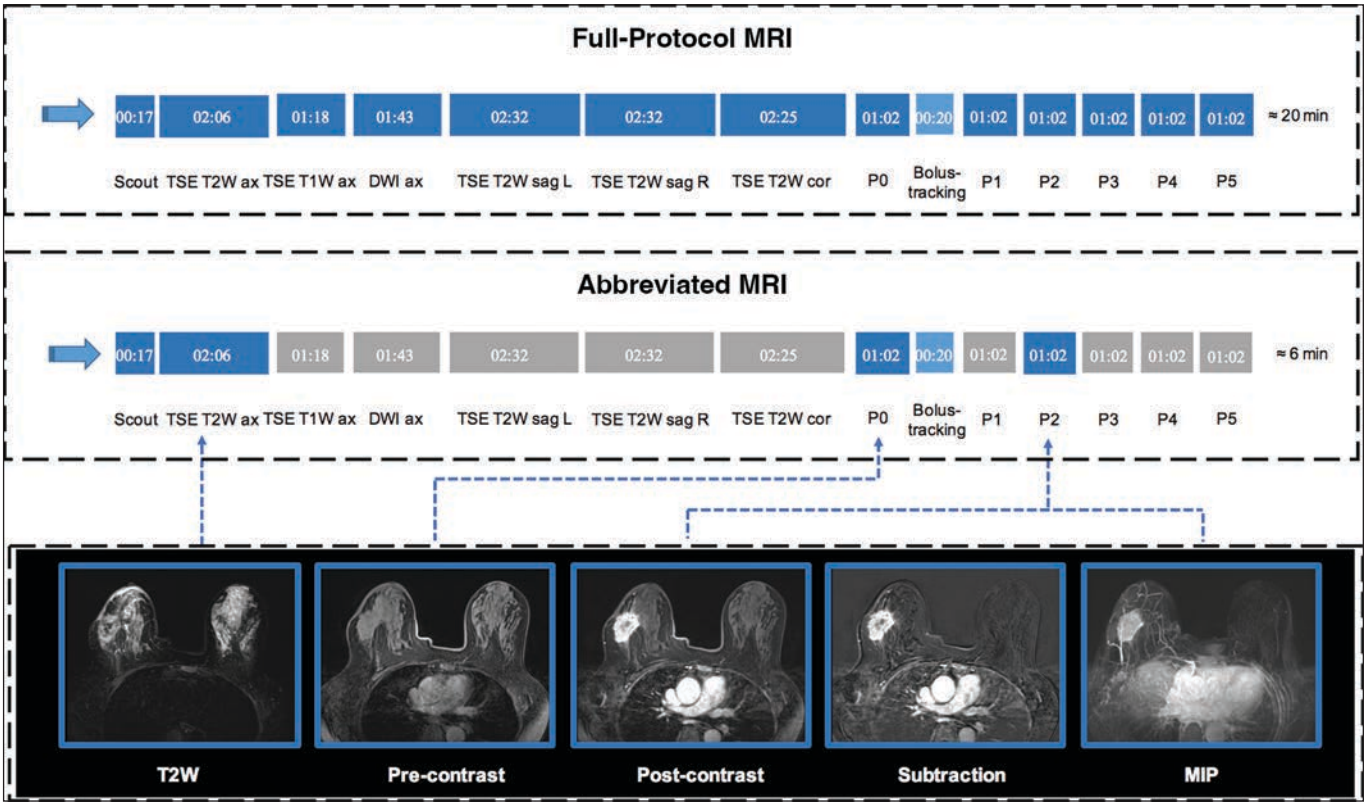

Fig. 2—Schematic presentation shows full (*top*) and abbreviated (*middle*) MRI protocols. Color corresponds with sequences included in (*blue*) and excluded from (*gray*) interpretations. Bottom row shows images evaluated for abbreviated MRI. TSE = turbo-spin echo, T2W = T2-weighted, ax = axial, T1W = T1-weighted, sag = sagittal, L = left, R = right, cor = coronal, P0 = precontrast phase, P1–P5 = postcontrast phases 1–5, MIP = maximum intensity projection.

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the second and third sessions were separated by 2 months. Examinations were reviewed in random order within each session. Time-intensity-curve analysis was performed only when reviewing full-protocol examinations. The complete MRI examinations performed before NAC were available for reference during each session. In addition, the radiologists were informed of the site of the cancer on the examination before NAC.

Within each session, the radiologists recorded whether the examination after NAC showed a residual enhancing lesion at the site of the cancer on MRI before NAC, defined as enhancement that was subjectively at least half as intense as that of normal parenchymal tissue on any available postcontrast phase [16]. When no residual enhancing lesion was identified, the patient was recorded as showing a radiologic complete response (rCR), and the lesion size was recorded as 0 mm. When a residual enhancing lesion was identified, the patient was recorded as not showing rCR, and the lesion size was recorded as the maximal diameter on any available postcontrast phase. In patients with multiple enhancing lesions that showed clear separation on MRI, the size of only the largest lesion was recorded. Finally, the readers manually recorded the interpretation time as the total duration for which the images were displayed on the monitor. Because the radiologists did not generate reports, these interpretation times did not include the potential time for report creation.

Histopathologic Evaluation

Histopathologic information was obtained from clinical reports; specimens from biopsy or surgery were not reviewed as part of this examination. All breast cancers were histologically diagnosed by core needle biopsy or vacuum-assisted biopsy performed between the initial MRI and NAC and underwent further pathologic assessment on the basis of the surgical specimen that was obtained after NAC. Information from biopsy specimens obtained before NAC included the histopathologic subtype, Ki-67 index, and the expression of estrogen receptor (ER), progesterone receptor (PR), and HER2. ER positivity and PR positivity were defined as the detection of at least 1% positively stained invasive tumor cells; patients with either ER positivity or PR positivity were classified as hormone-receptor (HR) positive. HER2 positivity was defined as a score of 3+ (overexpression) or 2+ with positive fluorescent in situ hybridization amplification. Molecular marker status was overall classified as HR positive and HER2 positive, HR positive and HER2 negative, HR negative and HER2 positive, or HR negative and HER2 negative. Pathologic assessment of surgical specimens served as the reference standard for determining pathologic complete response (pCR). Patients with Miller-Payne grade 5 (histopathologic absence of invasive tumor in the surgically resected breast specimens, with or without the presence of residual ductal carcinoma in situ [17]) were categorized as achieving pCR; pathologic tumor size in these patients was recorded as 0 mm. Patients with Miller-Payne grades 1–4 were categorized as not achieving pCR; in these patients, the pathologist recorded the maximum diameter of the identified residual tumor. The determination of pCR was based only on assessment of breast lesions; axillary lymph node status was not considered [16, 18, 19].

Statistical Analysis

Clinical and pathologic characteristics of the study sample were summarized and stratified by presence versus absence of pCR. The two patient groups were compared using the chi-square test for categoric variables and the independent-sample *t* test for continuous variables. Interpretation times were compared between abbreviated and full-protocol MRI using the Wilcoxon rank sum test. For both abbreviated and full-protocol MRI, intrareader and interreader agreement for the determination of rCR were assessed using Cohen kappa coefficients and Fleiss kappa coefficients, respectively, and interpreted according to the criteria of Landis and Koch [20]: less than 0.00, no agreement; 0.00–0.20, slight agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; and 0.81–1.00, almost perfect agreement. Sensitivity, specificity, and accuracy for detection of pCR were determined. Sensitivity was calculated as the percentage of patients with pCR who were classified as rCR by MRI. Specificity was calculated as the percentage of patients without pCR who were classified without rCR by MRI. Accuracy was calculated as the percentage of patients in whom the presence versus absence of pCR was correctly classified by rCR. The sensitivity, specificity, and accuracy were compared between protocols using McNemar test. The association of residual tumor size between MRI after NAC and pathologic assessment was assessed using Pearson correlation coefficient and Bland–Altman method. The correlation was considered to be strong if greater than 0.700. Results regarding interpretation time and diagnostic performance were computed for both individual radiologists and for pooled readings among the two groups of radiologists; the comparisons between groups of radiologists used a hierarchic approach to account for intrapatient clustering. All assessments were performed using the interpretations from the first of the two interpretations for each protocol (abbreviated and full), aside from the assessments of intrareader agreement for each protocol. A p value less than .05 was considered statistically significant. Data analyses were conducted using SPSS 26.0 (SPSS Statistics) and R software (version 4.1.2).

Results

Study Sample

The 203 patients had a mean age of 52.1 ± 11.2 [SD] years (range, 27–88 years); all patients were women. A total of 153 (75.4%) patients did not achieve pCR, and 50 (24.6%) patients achieved pCR. Clinical and pathologic characteristics of patients with and without pCR are compared in Table 1. Patients with and without pCR showed statistically significant differences in the distribution of molecular marker status ($p < .001$), with patients with pCR most commonly being HR negative and HER2 negative (34.0%), and patients without pCR most commonly being HR positive and HER2 negative (58.8%). The two groups showed no significant difference in terms of age, menopausal status, tumor location, histopathologic subtype, or Ki-67 status (all $p > .05$).

Reader Interpretation Times

Table 2 summarizes interpretation times for the two protocols. For general radiologists, the median interpretation time ranged from 48 to 66 seconds for abbreviated MRI and from 77 to 96 sec-

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TABLE 1: Clinical and Pathologic Characteristics of Included Patients

Characteristic	Total (*n* = 203)	No pCR (*n* = 153)	pCR (*n* = 50)	*p*[a]
Age (y), mean ± SD	52.1 ± 11.2	52.7 ± 11.5	50.4 ± 10.1	.20
Menopausal status				.21
Premenopausal	86 (42.4)	61 (39.9)	25 (50.0)	
Postmenopausal	117 (57.6)	92 (60.1)	25 (50.0)	
Tumor location				.47
Left	121 (59.6)	89 (58.2)	32 (64.0)	
Right	82 (40.4)	64 (41.8)	18 (36.0)	
Molecular marker status (%)				**< .001**
HR positive, HER2 positive	35 (17.2)	25 (16.3)	10 (20.0)	
HR positive, HER2 negative	103 (50.7)	90 (58.8)	13 (26.0)	
HR negative, HER2 positive	25 (12.3)	15 (9.8)	10 (20.0)	
HR negative, HER2 negative	40 (19.7)	23 (15.0)	17 (34.0)	
Ki-67 status (%)				.10
≥ 20	167 (82.3)	122 (79.7)	45 (90.0)	
< 20	36 (17.7)	31 (20.3)	5 (10.0)	
Histopathologic subtype				.42
NST	188 (92.6)	143 (93.5)	45 (90.0)	
Other	15 (7.4)	10 (6.5)	5 (10.0)	

Note—Unless otherwise indicated, data are expressed as number of patients, with percentage in parentheses. Percentages may not sum to 100 owing to rounding. pCR = pathologic complete response, HR = hormone receptor (classified as positive if either estrogen-receptor positive or progesterone-receptor positive), NST = invasive carcinoma of no special type.

[a]Listed in bold when statistically significant at $p < .05$.

TABLE 2: Interpretation Time of the Two Breast MRI Protocols

Reader	Protocol		*p*
	Abbreviated	Full	
General radiologist			
Reader 1	59 (43–69)	78 (65–92)	< .001
Reader 2	48 (43–55)	77 (65–89)	< .001
Reader 3	66 (52–75)	96 (88–106)	< .001
All 3	57	83	< .001
Breast radiologist			
Reader 4	47 (38–53)	88 (76–95)	< .001
Reader 5	44 (36–56)	79 (75–89)	< .001
Reader 6	50 (44–60)	89 (86–99)	< .001
All 3	48	86	< .001

Note—Times expressed in seconds as medians, with IQR in parentheses.

onds for full-protocol MRI. For breast radiologists, the median interpretation time ranged from 44 to 50 seconds for abbreviated MRI and from 79 to 89 seconds for full-protocol MRI. Pooling across readers, the median interpretation time was significantly shorter for abbreviated MRI than for full-protocol MRI for general radiologists (57 vs 83 seconds, respectively; $p < .001$) and for breast radiologists (48 vs 86 seconds, $p < .001$); the interpretation time was also significantly shorter for abbreviated than for full-protocol MRI for all six radiologists individually (all $p < .001$).

Intraobserver and Interobserver Agreement for the Assessment of Radiologic Complete Response

Table 3 summarizes intraobserver and interobserver agreement for the two protocols. Intraobserver agreement for abbreviated MRI was substantial for both general radiologists (κ = 0.74–0.76) and breast radiologists (κ = 0.70–0.76). Intraobserver agreement for full-protocol MRI was substantial for general radiologists (κ = 0.73–0.77) and ranged from substantial to nearly perfect for breast radiologists (κ = 0.76–0.81). Interobserver agreement for abbreviated MRI was substantial for both general radiologists (κ = 0.75) and breast radiologists (κ = 0.74) and for full-protocol MRI was substantial for both general radiologists (κ = 0.76) and breast radiologists (κ = 0.77).

Diagnostic Performance of MRI After Neoadjuvant Chemotherapy for Assessment of Pathologic Complete Response

Table 4 summarizes readers' diagnostic performance for determining the presence of pCR on MRI after NAC. Across readers, for abbreviated MRI, sensitivity ranged from 52.0% to 62.0%, specificity from 92.2% to 94.7%, and accuracy from 82.3% to 86.7%, and for full-protocol MRI, sensitivity ranged from 54.0% to 62.0%, specificity from 94.8% to 98.0%, and accuracy from 85.7% to 88.7%. Abbreviated MRI, compared with full-protocol MRI, showed no significant difference for general radiologists in sensi-

TABLE 3: Intraobserver and Interobserver Agreement (κ) of the Two Breast MRI Protocols for the Determination of Radiologic Complete Response

Reader	Protocol	
	Abbreviated	Full
Intraobserver		
General radiologist		
Reader 1	0.74	0.73
Reader 2	0.75	0.73
Reader 3	0.76	0.77
Breast radiologist		
Reader 4	0.76	0.80
Reader 5	0.75	0.81
Reader 6	0.70	0.76
Interobserver		
General radiologists	0.75	0.76
Breast radiologists	0.74	0.77

tivity (54.7% vs 57.3%, $p > .99$), specificity (92.8% vs 95.6%, $p = .29$), or accuracy (83.4% vs 86.2%, $p = .30$), nor significant difference for breast radiologists in sensitivity (60.0% vs 61.3%, $p > .99$), specificity (94.6% vs 97.4%, $p = .22$), or accuracy (86.0% vs 88.5%, $p = .30$). In addition, abbreviated MRI and full-protocol MRI showed no significant difference in sensitivity, specificity, or accuracy for any reader individually (all $p > .05$). Figures 3 and S1 (available in the online supplement) show examples of patients in whom abbreviated and full-protocol MRI both correctly classified the presence or absence of pCR, and Figure S2 (available in the online supplement) shows an example of a patient in whom abbreviated and full-protocol MRI both incorrectly classified the presence of pCR.

Assessment of Residual Tumor Size After Neoadjuvant Chemotherapy

Table 5 summarizes results regarding comparisons of residual tumor size between MRI after NAC and pathologic assessment. The mean tumor size on pathologic assessment was 16.5 ± 15.4 mm. The mean tumor size on abbreviated MRI for general radiologists ranged from 16.5 to 16.6 mm and for breast radiologists from 16.4 to 16.6 mm, and on full-protocol MRI for general radiologists from 17.1 to 17.2 mm and for breast radiologists from 17.2 to 17.4 mm. The correlation with pathologic tumor size was strong for both protocols for all readers ($r = 0.844–0.866$). Figure S3 (available in the online supplement) shows the Bland-Altman plots for each reader and the agreement between MRI and pathologic assessments of tumor size. The mean difference relative to pathology for abbreviated MRI ranged for general radiologists from −0.19 to 0.03 mm and for breast radiologists from −0.15 to −0.05 mm, and for full-protocol MRI ranged for general radiologists from 0.57 to 0.65 mm and for breast radiologists from 0.66 to 0.79 mm. Figure S4 (available in the online supplement) shows a patient in whom residual tumor size was overestimated by full-protocol MRI but not by abbreviated MRI.

Discussion

This multireader study compared the performance of general radiologists and breast radiologists in the interpretation of abbreviated MRI and full-protocol MRI for evaluation of NAC response in patients with breast cancer from two different hospitals. For all readers, interpretation times were significantly lower for abbreviated MRI than for full-protocol MRI. Intrareader agreement and interreader agreement were excellent for both protocols. The two protocols showed no significant difference in sensitivity, specificity, or accuracy for detection of pCR for any reader. Also, for both groups of readers, pathologic residual tumor size was more closely predicted by abbreviated MRI than by full-protocol MRI, which tended to provide size overestimates. The findings indicate the potential utility of abbreviated MRI in evaluating NAC response by both general radiologists and dedicated breast radiologists.

TABLE 4: Diagnostic Performance of the Two Breast MRI Protocols for the Determination of Pathologic Complete Response

Reader	Sensitivity			Specificity			Accuracy		
	Abbreviated	Full-Protocol	*p*	Abbreviated	Full-Protocol	*p*	Abbreviated	Full-Protocol	*p*
General radiologist									
Reader 1	52.0 (26/50)	54.0 (27/50)	> .99	92.2 (141/153)	96.1 (147/153)	.07	82.3 (167/203)	85.7 (174/203)	.12
Reader 2	56.0 (28/50)	58.0 (29/50)	> .99	93.5 (143/153)	96.1 (147/153)	.29	84.2 (171/203)	86.7 (176/203)	.30
Reader 3	56.0 (28/50)	60.0 (30/50)	.75	92.8 (142/153)	94.8 (145/153)	.45	83.7 (170/203)	86.2 (175/203)	.30
All	54.7 (82/150)	57.3 (86/150)	> .99	92.8 (426/459)	95.6 (439/459)	.29	83.4 (508/609)	86.2 (525/609)	.30
Breast radiologist									
Reader 4	62.0 (31/50)	60.0 (30/50)	> .99	94.8 (145/153)	98.0 (150/153)	.06	86.7 (176/203)	88.7 (180/203)	.42
Reader 5	58.0 (29/50)	62.0 (31/50)	.75	94.1 (144/153)	97.4 (149/153)	.06	85.2 (173/203)	88.7 (180/203)	.12
Reader 6	60.0 (30/50)	62.0 (31/50)	> .99	94.8 (145/153)	96.7 (148/153)	.51	86.2 (175/203)	88.2 (179/203)	.48
All	60.0 (90/150)	61.3 (92/150)	> .99	94.6 (434/459)	97.4 (447/459)	.22	86.0 (524/609)	88.5 (539/609)	.30

Note—Data expressed as percentage, with numerator and denominator in parentheses.

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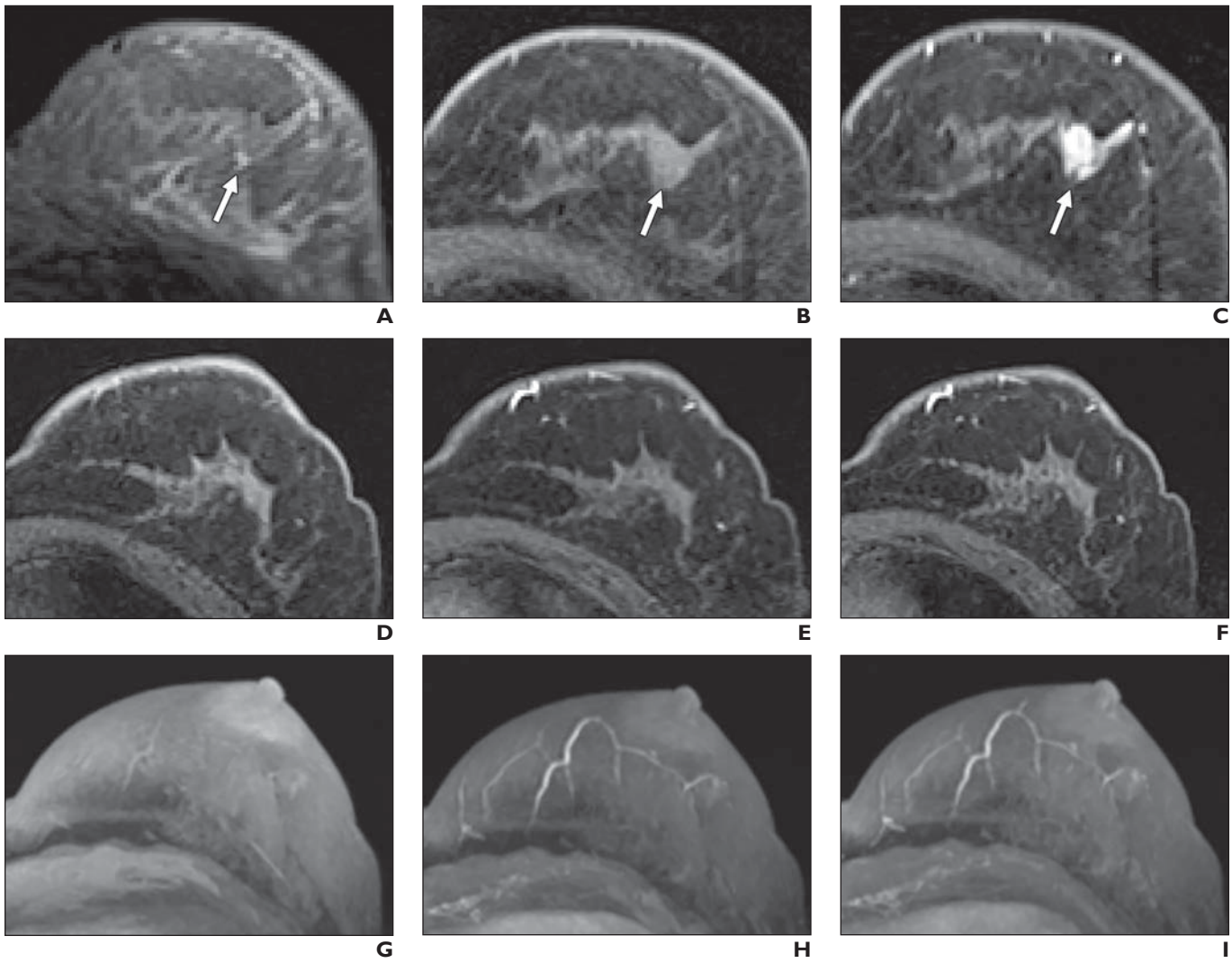

Fig. 3—61-year-old woman with invasive carcinoma of left breast.
A–C, MRI was performed before initiation of neoadjuvant chemotherapy (NAC). Axial fat-suppressed T2-weighted image (**A**) shows irregular hyperintense lesion (*arrow*). Axial precontrast fat-suppressed T1-weighted image (**B**) shows associated isointensity (*arrow*). Axial postcontrast fat-suppressed T1-weighted image (**C**) shows associated heterogeneous enhancement (*arrow*).
D–I, MRI was performed after completion of NAC. Axial precontrast fat-suppressed T1-weighted image (**D**), axial postcontrast fat-suppressed T1-weighted image (phase 2 of 5) (**E**), and axial postcontrast fat-suppressed T1-weighted image (phase 5 of 5) (**F**) show no clear residual enhancing lesion. Corresponding maximum-intensity-projection images for precontrast acquisition (**G**), phase 2 (**H**), and phase 5 (**I**) also show no clear residual enhancing lesion. Findings are consistent with radiologic complete response by both abbreviated MRI and full-protocol MRI. Postoperative histopathologic evaluation identified fibrous tissue hyperplasia, but no invasive carcinoma. Case was assessed as Miller-Payne grade 5, consistent with pathologic complete response.

TABLE 5: Comparison of Residual Tumor Size Between Pathology and Each of Two Breast MRI Protocols

	Abbreviated			Full-Protocol		
Reader	Residual Tumor Size (mm)	*r*	Mean Difference[a] (mm)	Residual Tumor Size (mm)	*r*	Mean Difference[a] (mm)
General radiologist						
Reader 1	16.6 ± 13.7	0.847	0.03	17.2 ± 14.0	0.853	0.59
Reader 2	16.5 ± 13.7	0.844	−0.06	17.1 ± 13.9	0.852	0.57
Reader 3	16.6 ± 15.5	0.848	−0.19	17.2 ± 13.8	0.850	0.65
Breast radiologist						
Reader 4	16.4 ± 13.6	0.856	−0.13	17.2 ± 14.0	0.860	0.66
Reader 5	16.5 ± 13.8	0.863	−0.05	17.4 ± 14.2	0.866	0.79
Reader 6	16.6 ± 15.5	0.861	−0.15	17.3 ± 14.2	0.865	0.77

Note—Mean tumor size (SD) on pathologic assessment was 16.5 ± 15.4 mm.
[a]From Bland-Altman analysis.

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The use of only a limited number of sequences for abbreviated MRI could have varying potential effects on cancer detection. After NAC, residual tumor may show delayed enhancement because of the antiangiogenic effects of chemotherapy, contributing to missed cancers [21–23]. On the other hand, reactive inflammation, fibrosis, or necrosis after NAC may result in areas of delayed enhancement that are appreciated only when evaluating full-protocol MRI, leading to overestimation of the presence of residual tumor for the full protocol [24, 25]. Despite these possibilities, in the current study, the two protocols showed no significant difference in any performance measure for any reader. Yirgin et al. [15] also compared abbreviated MRI and full-protocol MRI for evaluation after NAC. However, their study included only 50 patients, examinations were interpreted only in consensus, and sensitivity and specificity were not computed.

Residual tumor size was consistently slightly overestimated by full-protocol MRI, but not by abbreviated MRI. In the study by Yirgin et al. [15], residual tumor sizes were consistently smaller for abbreviated MRI than for full-protocol MRI, yet the sizes were smaller with respect to pathologic sizes for both protocols. In the study by Kim et al. [26], residual tumor sizes after NAC were likewise smaller on early than on delayed postcontrast MRI. In their study, early postcontrast images underestimated histologic sizes, and delayed postcontrast images overestimated histologic sizes when considering invasive tumor size alone; however, early and delayed postcontrast images both underestimated histologic sizes when considering total tumor sizes inclusive of in situ components. The smaller sizes obtained by earlier than delayed postcontrast images have been attributed to the previously noted delayed enhancement of residual tumor after antiangiogenic chemotherapy [21–23]. This phenomenon is important to recognize when using abbreviated MRI for evaluation after NAC.

The significantly reduced interpretation times for abbreviated MRI are consistent with previous reports of abbreviated MRI performed for various indications [9, 15, 27, 28]. In an evaluation of abbreviated MRI for assessment after NAC, Yirgin et al. [15] reported a mean interpretation time of 10 minutes for abbreviated MRI compared with 20 minutes for full-protocol MRI in NAC response evaluation. Those interpretation times are substantially longer than the interpretation times in the current study, likely in part relating to differences between studies in the approach used for response assessment. The earlier study assessed response using RECIST 1.1, with multiple possible response categories from which to select [15]. Time was also needed in the earlier study for the readers to reach consensus. The reduction in interpretation time when using abbreviated MRI could be useful in addressing radiologist workloads, particularly as breast MRI is adopted for an expanding array of clinical indications.

This study has limitations. First, despite inclusion of patients from two hospitals, the sample size was not large. Second, the study was conducted retrospectively, with abbreviated MRI extracted from full-protocol MRI examinations. Prospective evaluation of patients who undergo true abbreviated examinations in a clinical setting remains warranted. Third, abbreviated MRI was evaluated only in the context of the MRI examination performed after the last NAC cycle and before surgery. Abbreviated MRI was not evaluated for monitoring after earlier NAC cycles. Fourth, only a single abbreviated MRI protocol was evaluated. Abbreviated MRI could potentially also include DWI. Fifth, axillary lymph node status was not included in NAC evaluation. Finally, reader assessment for residual tumor was evaluated in a binary fashion; diagnostic confidence was not recorded.

In conclusion, multiple general and breast radiologists found no significant difference between abbreviated and full-protocol MRI in sensitivity, specificity, or accuracy for detection of pCR after NAC. Intrareader and interreader agreement were similar between the two protocols. Full-protocol but not abbreviated MRI tended to yield slight overestimates of pathologic tumor sizes. Interpretation times were significantly shorter for abbreviated MRI for all readers. The findings indicate that abbreviated protocols may facilitate incorporation of MRI into clinical algorithms for breast cancer response assessment after NAC.

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Editorial Comment: Abbreviated MRI for Breast Cancer Neoadjuvant Chemotherapy Response Assessment—One Step Forward in an Important Research Pathway

Neoadjuvant chemotherapy (NAC) is an increasingly used therapeutic option for patients with breast cancer. Breast MRI is considered the reference standard for assessment of response to NAC. Yet, MRI poses logistic challenges: limited availability, relatively high cost, possible patient intolerance, and long examination and interpretation times. Abbreviated MRI (AB-MRI) has been welcomed by the radiology community as a valuable approach for mitigating these problems [1].

In breast imaging, AB-MRI has been mostly studied for screening [2]. One prior study investigated AB-MRI for the evaluation of NAC response [3]. The current study further investigates the role of AB-MRI for NAC monitoring, but with a larger sample size than the earlier study and a unique design, comparing the diagnostic performance of multiple breast and general radiologists between AB-MRI and full-protocol MRI. Key findings include noninferior performance of AB-MRI for predicting pathologic complete response regardless of radiologists' breast imaging expertise, significantly shorter interpretation times for AB-MRI, and comparable intrareader and interreader agreement for AB-MRI and full-protocol MRI. A novel finding is that full-protocol MRI, but not AB-MRI, slightly overestimated pathologic residual tumor size.

This retrospective study is an important step for developing a method that could ease radiologists' daily workloads and improve patient throughput, promoting equitable access to appropriate high-quality advanced imaging. Notwithstanding the encouraging results, relevant gaps remain. Ongoing needs for AB-MRI include protocol refinement and standardization, heightened attention to the complete examination time (i.e., table time), validation by prospective multicenter trials, cost-effectiveness analysis, reimbursement mechanisms, and comparison with contrast-enhanced mammography. Indeed, addressing these issues will be crucial to fully understand how this promising tool can be implemented in clinical practice.

Lígia Pires-Gonçalves, MD
Instituto Português de Oncologia do Porto
Porto, Portugal
ligiagoncalves@ipoporto.min-saude.pt

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