



Preliminary Local Experience with Breast Magnetic Resonance Imaging on Surgical Planning and Outcomes

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Abstract

Background: Breast Magnetic Resonance Imaging (MRI) has been shown superior to mammography and ultrasound in terms of cancer detection and tumour size estimation. However, breast MRI is seldom done at our unit because of its cost.

Aims: We reviewed 31 women (32 cancers) who had pre-operative MRI and evaluated the impact of additional MRI-detected lesions on surgical planning and margin status.

Results: Breast MRI was done to evaluate suitability for breast conservation in 20 women and as further evaluation of inconclusive or discordant mammography and ultrasound findings in the other 11. Additional lesions were detected in 24 of 31 (77.4%) women. Additional cancer foci occult on mammography and ultrasound were detected in 10 women (32.2%); with additional cancers found in the contralateral breast in 3 of these women. Surgical margins were found inadequate in 5 of 18 (27.8%) women who underwent wide local excision, in whom a larger, but statistically non-significant, difference between imaging and actual pathological tumour size was observed. Both ultrasound and MRI tumour size estimation correlated significantly with actual pathological tumour size, with tumour size estimation on breast MRI being most precise ($P < 0.001$, $\rho = 0.732$, 95% CI: 0.505 – 0.864). Ultrasound tended to underestimate tumour size more frequently compared to breast MRI ($P < 0.001$ and $P = 0.956$ respectively).

Conclusion: Breast MRI detected tumours occult on mammography and ultrasound and estimated tumour size most accurately. Two-thirds of additional lesions detected on MRI were non-malignant. Breast conservation rate was high in those with normal or benign MRI findings.



Introduction

Breast Magnetic Resonance Imaging (MRI) may not be a part of routine breast cancer work-up in many units, but is a useful adjunct to conventional mammography and breast ultrasound in certain instances [1]. It has been shown to detect additional cancer foci, both in the breast with known cancer as well as in the contralateral breast [2-5] and can delineate disease extent more accurately than either mammography or ultrasound [6,7]. At our unit, MRI use is limited to women keen for breast conservation but who are deemed to be at an increased risk of occult foci, most often because of tumour histology, dense breast tissue or a higher than average lifetime risk of breast cancer. Only a small fraction of the women diagnosed with breast cancer at our unit receive breast MRI. In our practice, many women eligible for breast conservation opt instead for mastectomy, for reasons that include a desire to avoid repeat surgery for inadequate surgical margins or radiation, a preconception that mastectomy offers superior long-term survival and a lesser concern for post-mastectomy cosmesis [8,9]. Even so, MRI use is very infrequent among those who opt for breast conservation because of its high cost. Apart from assessing suitability for breast conservation, breast MRI was most often done as a problem solving tool, when mammography and ultrasound findings were discordant with each other or with the clinical findings.

Aims

In this study, we examined 31 women who had breast MRI as part of the diagnostic work-up for newly diagnosed breast cancer. We aimed primarily to determine how breast MRI findings influenced the decision with regards to the type of surgery, specifically whether these women subsequently underwent mastectomy or a contralateral procedure. We also sought to evaluate how tumour size estimation on the MRI affected re-excision rates when breast conservation was done.

Methods

In this study, we examined 31 women who had breast MRI done between 1st January 2006 to 31st December 2020, which represented 0.6% of the women newly diagnosed with breast cancer at our unit. Indications for the breast MRI were documented. Additional lesions detected on MRI, but not reported on the initial mammography and breast ultrasound, were evaluated and stratified into benign, indeterminate or suspicious based on MRI features, and outcomes of biopsies or any resultant changes in the surgical plan were evaluated. A change in the surgical plan was defined as a conversion from breast conservation to mastectomy or a requirement for contralateral procedures. We also examined how well tumour size estimation made on mammography, breast ultrasound and breast MRI correlated with the actual pathological tumour size as determined on histological analysis. The size difference was tested for normality using Shapiro-Wilk test. Spearman rank correlation (rho coefficients) was computed as the Shapiro-Wilk test $P < 0.05$ for the continuous variables pathological whole size and MRI size. The Wilcoxon sign rank test was used to test for the median difference between pathological whole tumour size and imaging tumour size. One-tailed sign test was carried out to determine any tumour size underestimation. Mann-Whitney test was done to compare median size differences between patients who had repeat excision after the initial breast conservation surgery. All statistical analyses were performed using the Stata package, release 15.0 (StataCorp, College Station, TX, USA). A P value of less than 0.05 was considered statistically significant.

Results

Median age of the 31 women with breast MRI done was 53 years (ranging from 23 to 77 years) and the ethnic distribution was skewed to include predominantly Chinese women. One woman was already known to have bilateral breast cancer after initial mammography and breast ultrasound. In all 31 women, the MRI had been done as part of the pre-operative surgical planning after biopsy proven breast cancer; 30 women had a newly diagnosed breast cancer, one woman a contralateral cancer. In 20 women (64.5%), breast MRI was done to exclude additional foci of disease which might affect their suitability for breast conservation. This included 17 women with biopsy proven invasive lobular carcinoma, 2 young women with dense breasts and 1 woman in whom the mammographic abnormality appear more extensive than the corresponding sonographic lesion. In the remaining 11 women, breast MRI was done as further work-up because of inconclusive or discordant initial imaging. In 3 women, there was a suggestion of architectural distortion on mammography without any corresponding sonographic lesion. In 4 women, both mammography and ultrasound showed no focal lesions corresponding to incidental enhancing lesions seen on computed tomography (2 women) or to account for abnormal clinical findings (2 women). Breast MRI was done to exclude an occult breast primary in 4 women who presented with metastatic axillary lymphadenopathy. Details are presented in Table 1.

Table 1: Demographic, and tumour characteristics of the 31 women who received pre-operative MRI in our unit from 2006 to 2020. MRI: Magnetic Resonance Imaging, CT: Computed Tomography. *invasive tumours only.

	n=31 (%)
Median age	53 (23 – 77)
Ethnicity	
Chinese	29 (93.5)
Malay	1 (3.2)
Indian	1 (3.2)
Others	1 (3.2)
Median tumour size on pre-operative mammography (mm) (range)	14.0 (5 – 14)
Median tumour size on pre-operative breast ultrasound (mm) (range)	12.5 (5 – 26)
Median tumour size on pre-op breast MRI (mm) (range)	20.5 (7 – 65)
Median pathological tumour size (mm) (range)	17.5 (1 – 60)
Disease stage	
DCIS	4 (12.9)
I	11 (35.5)
II	13 (41.9)
III	3 (9.7)
Tumour oestrogen receptor (ER) status	
Positive	27 (84.4)
Negative	5 (15.6)
Tumour progesterone receptor (PR) status	
Positive	27 (84.4)
Negative	5 (15.6)
Tumour human epidermal growth factor receptor (HER)-2 status*	
Positive	2 (7.4)
Negative	25 (92.6)

Overall, additional lesions were detected on breast MRI in 24 of 31 (77.4%) women. Additional cancer foci occult on mammography and ultrasound were detected in 10 women (32.2%); with 7 being confirmed on pre-operative biopsy and 3 thought likely to be multifocal disease based on MRI features being similar to the known cancer. Three of these additional cancers (9.6%) were found in the contralateral breast. Lesions in 10 women were reported to have benign features, including 2 lesions that were of unknown clinical significance and possibly background enhancement. None of these were biopsied. The other 14 women had lesions that were considered suspicious on MRI and 7 of them underwent a biopsy. Malignancy was confirmed in 4 women (2 DCIS and 2 invasive carcinoma) and the other 3 lesions returned as atypical ductal hyperplasia, atypical apocrine adenosis and fibroadenomatoid change. Seven women with suspicious MRI lesions did not undergo a biopsy; 3 women were thought likely to have multifocal disease and all underwent mastectomy. Four others proceeded with wide local excision, with one of them eventually undergoing a mastectomy after surgical margins were found inadequate. Additional significant lesions were detected in the contralateral breast in 5 women and all these women required surgery (1 confirmed with DCIS, 2 with invasive carcinoma, 1 with atypical ductal hyperplasia and 1 with atypical apocrine adenosis). Of the 4 women being evaluated for metastatic axillary lymphadenopathy, mammographically and sonographically occult cancers were found in 2. An indeterminate lesion was found in one of the other two women. This was non-malignant on pre-operative biopsy, but was excised in view of possible radiological-pathological discordance and proven on final histology to be stromal fibrosis. No disease in the breast was found on surveillance in these 2 women (25 months in one and more than 10 years in the other).

Of the 20 women who were evaluated for their suitability for breast conservation, additional lesions were detected in 16 women. Four women were found with additional suspicious foci in the ipsilateral breast, likely multifocal disease, and another 2 women were found with contralateral cancers not previously detected on mammography or ultrasound. All these 6 women had invasive lobular cancers. Additional indeterminate lesions were found in 2 women (both were papillary lesions on biopsy) and benign lesions were noted in another 8. Fifteen of these women proceeded with wide local excision.

Decision for surgery

Overall, 18 women proceeded with wide local excision, including 15 of the 20 women who had done the MRI to confirm

their suitability for breast conservation. Apart from the one woman who underwent bilateral wide local excision for bilateral cancers, additional breast MRI findings led to a contralateral procedure being performed in 5 women; one woman underwent wide excision for an indeterminate lesion that was subsequently found to be an invasive ductal carcinoma, 2 women underwent mastectomy for contralateral cancers detected on MRI and 2 women opted for a prophylactic mastectomy at the same setting. Five of the 20 women opted for mastectomy after breast MRI, including the 4 women who were likely to have multifocal disease; 1 of these 5 women also underwent a contralateral mastectomy after a biopsy-proven cancer was found on MRI and another woman opted for a prophylactic mastectomy at the same setting.

Estimation of tumour size

We next evaluated how well mammography, breast ultrasound and breast MRI estimated tumour size. Mammography size estimation was within 10mm of actual pathological tumour size in 12 cases. Mammography over-estimated the tumour size in 1 case (by 25mm) and under-estimated it (by 27mm) in another case. However, it should be noted that the tumour was mammographically occult in 7 cases and size was not reported in 11 cases. A non-significant correlation with actual pathological tumour size was observed ($P=0.397$, $\rho=0.246$, 95% CI: -0.327 to 0.687). The tumour was sonographically occult in 8 women. Correlation with actual pathological size was statistically significant ($P=0.011$, $\rho=0.510$, 95% CI: 0.135 – 0.758), with sonographic size estimation being within 10mm of actual pathological tumour size in 19 tumours. Five tumours were over-estimated on ultrasound (by up to 32mm). Apart from 2 cases where no suspicious mass was detected on breast MRI (both women with metastatic axillary lymphadenopathy and had also negative mammography and ultrasound findings), MRI tumour size correlated significantly with actual pathological tumour size ($P<0.001$, $\rho=0.732$, 95% CI: 0.505 – 0.864). Tumour size estimation on MRI matched that of the actual tumour in 23 cases (within 10mm of pathological tumour size), was over-estimated (by up to 30mm) in 5 tumours and was under-estimated (by up to 34mm) in 2 tumours. Tumour size estimation on breast MRI corresponded with actual pathological tumour size most closely ($\rho=0.732$, $P<0.001$, 95% CI: 0.505 – 0.864) (Table 2). Comparing breast ultrasound to MRI, ultrasound tended to underestimate the tumour size more often compared to breast MRI ($P<0.001$, $\rho=0.732$, 95% CI: 0.505 – 0.864) (Table 2), while MRI tumour size estimation was more precise and accurate (Figure 1).

Table 2: Median difference between tumour size on imaging and actual pathological size for the 31 women, stratified by the imaging modalities. *18 cases excluded either because cancer was mammographically occult or tumour size was not reported; *8 cases excluded because cancer was sonographically occult; #2 cases excluded because no tumour was detected on MRI. CI: Confidence Interval.

	Mammography	Breast Ultrasound	Breast MRI
Spearman rho (95% CI), P value	0.246 (-0.327 to 0.687), P = 0.397	0.510 (0.135 to 0.758), P = 0.011	0.732 (0.505 to 0.864), P < 0.001
Median size difference (mm) (range)	0.5 (-27 – 25)*	5.5 (-9 – 32)*	-1.5 (-34 – 30)#
One-tailed rank test	P = 0.387	P < 0.001	P = 0.956
Estimation of pathological size, within 10mm (%)	12 (37.5)	19 (59.4)	23 (71.9)

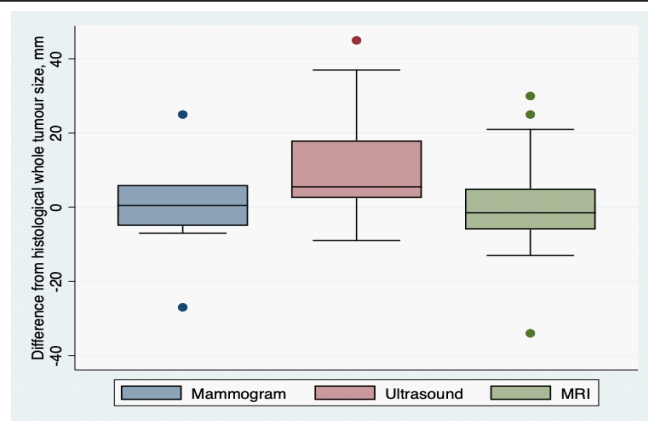


Figure 1: Boxplots showing the spread and variability of the tumour size estimation stratified by the three imaging modalities compared to pathological tumour size (n=32).

Influence of breast MRI findings on surgical margins

Surgical margins were inadequate in 5 of the 18 women (27.8%) who underwent wide local excision. Three women had no additional lesions detected in the ipsilateral breast on MRI

and tumour size on MRI was within 12mm of the actual pathological size in these 3. In one other woman, MRI had picked up an additional lesion within 1cm of the tumour, but this had been deemed benign and no pre-operative biopsy was done. In another woman, MRI showed a more extensive lesion than seen on the ultrasound but MRI had over-estimated the tumour size by only 6mm. No residual tumour was found on re-excision in 4 of the 5 women. The one woman with residual tumour at the second surgery eventually underwent a mastectomy after the re-excision margins were again found inadequate.

In the 5 women with inadequate margins after the first wide local excision, MRI had estimated tumour size more accurately than either mammography or ultrasound. Median difference between pathological tumour size and MRI tumour size was 5mm (ranging from -9 to 30mm), while both mammography and ultrasound tended to underestimate actual tumour size (Table 3). These 5 tumours were observed to have larger, though non-significant, median differences in estimated tumour size on both mammography and ultrasound compared to those in the 13 other women with adequate margins after the first wide local excision (Table 3).

Table 3: Median size difference between imaging modality and pathological tumour size in 18 women who underwent wide local excision.

	Women with inadequate margins after first wide local excision (n = 5)	Women with adequate margins after first wide local excision (n = 13)	P value
Median mammographic size difference (mm) (range)	10 (-5 to 25)	5 (-27 to 6)	0.791
Median ultrasound size difference (mm) (range)	18 (-9 to 32)	3 (-5 to 18)	0.568
Median MRI size difference (mm) (range)	5 (-9 to 30)	-1.5 (-34 to 21)	0.459

Discussion

The use of breast MRI prior to surgery has increased over the years, with some centres reporting that up to 73% of newly diagnosed breast cancer patients received an MRI [10]. Several studies have shown breast MRI to be more sensitive than conventional mammography and breast ultrasound, the two modalities routinely used to work up breast cancers for surgery [11-15]. Breast ultrasound is often used to complement mammography in the work-up for clinically suspicious lesions at our unit because of concerns that the false negative rate of mammography may be higher due to the larger numbers of women having dense breasts. However, we observed in our study that a significant number of MRI-detected cancers were not detected on initial ultrasound assessment. While second-look ultrasound is often done in such instances, this does suggest that MRI is superior to combined mammography and ultrasound assessment and supports our practice of including MRI in instances where the probability of multifocal or occult disease is high. While most often used to exclude additional occult foci in women with invasive lobular cancers keen for breast conservation at our unit, MRI was also frequently to verify discordant findings or subtle abnormalities on mammography.

Breast MRI has been reported to detect mammographically occult disease in the same breast in 31% of patients and also additional cancers in the contralateral breast in 4% of patients [16]. Additional lesions were found in 77% of women who underwent MRI in our study. Additional cancer foci were found in 32% of these women and 10% of the women had contralateral disease not detected on initial mammography and ultrasound.

The higher rates observed in our study is likely because MRI was done in a highly selected group of women who had a higher probability of multifocal disease and missed cancers [10,17].

One of the main criticisms of pre-operative MRI use has been that the increased sensitivity comes at the expense of high false positive biopsies. The greater anxiety caused by additional MRI-detected lesions has been linked to a trend towards mastectomy, even bilateral mastectomy [18,19]. In our study, 22% of women underwent biopsy for suspicious MRI-detected lesions and half were confirmed malignant. Of note was that none of the 10 women found with benign lesions on MRI underwent a biopsy and only one woman opted for mastectomy following the MRI while the rest proceeded with wide local excision. Overall, 75% of the women in whom breast MRI was done to confirm their suitability for breast conservation did in fact proceed with wide local excision, suggesting that the exclusion of additional disease foci provided adequate reassurance to the majority of women. However, it can also be said that these women were in fact more inclined towards breast conservation in the first place since the MRI would not have been done if they had opted for mastectomy upfront. Similar trends have been reported by others. Killelea and colleagues also observed that women with normal or benign MRI findings were in fact more likely to choose breast conservation [10]. Likewise, Houssami and colleagues also reported a very low rate of conversion from wide local excision to mastectomy in women with MRI-detected lesions that were proven non-malignant on pre-operative biopsy [17]. Breast MRI also provided assurance that mastectomy

was not required when no foci was found in the breast in instances of metastatic axillary lymphadenopathy.

Breast MRI has also been shown superior to mammography and ultrasound in determining tumour extent. Like others, we too observed that tumour size was most accurately estimated on MRI, with 72% of tumours being within 10mm of the size estimated on MRI [20,21]. This, together with the observation that all cancers were visualised on MRI, would suggest that MRI is useful for surgical planning. However, MRI can also over-estimate tumour size [17,22]. Over-estimation, of up to 3cm, occurred in 5 women, which is significant and can potentially result in a strong push towards mastectomy considering the smaller breast volumes of our women. Compared to MRI, we observed that tumour size was more often under-estimated on ultrasound, an observation also reported by other groups [23,24]. Breast MRI showed the best overall correlation with the pathological tumour size compared to mammography or ultrasound. Surgical margins were inadequate in 27% of the women who underwent wide local excision in our study. Comparatively, a previous study from our unit found inadequate margins in 34% of women who had only pre-operative mammography and ultrasound assessments [25]. This could indicate the benefit of more accurate tumour size estimation on MRI, but the small study sample precludes further analysis. It remains to be conclusively proven that pre-operative MRI reduces re-excision or local recurrence rates.

Conclusion

Breast MRI is performed very selectively in our unit primarily because of cost concerns. Additional lesions were detected in 77% but less than half of these were clinically significant and affected surgical management. The majority of women who were being assessed for suitability for breast conservation proceeded with wide local excision and surgical margins were adequate in 73%.

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