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ORIGINAL ARTICLE

Image-guided Localisation of Nonpalpable Breast Lesions: a Comparative Analysis of Magnetic Seeds and Hookwires in an Asian Population

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ABSTRACT

Objectives: *To compare the procedural outcomes of magnetic seed localisation and hookwire localisation (HWL) of nonpalpable breast lesions in an Asian population.*

Methods: *We performed a retrospective review of 91 nonrandomised female patients who underwent breast surgery after image-guided magnetic seed localisation or HWL from July 2019 to June 2021. Rates of placement success (defined as marker-lesion distance <10 mm), lesion detection, marker retrieval, and complications, were compared.*

Results: *A total of 48 patients received magnetic seeds, and 43 patients received hookwires for preoperative localisation; a total of 100 lesions (50/100, 50.0% Magseed vs. 50/100, 50.0% hookwire) were marked and excised. Magnetic seeds were placed 0 to 126 days before surgery (median=14); of the 50 lesions marked, 22 were removed on the same day and 28 on a later day. Placement success was identical between the two groups, 98.0% magnetic seeds versus 98.0% hookwire. All lesions were detected at the first operation and successfully excised; all markers were removed intact without complications.*

Conclusion: *Magnetic seed localisation demonstrated comparable procedural success and safety to conventional HWL in Asian patients with thinner and denser breasts. It could be an effective alternative to HWL, with the additional advantage of decoupling localisation and surgery dates.*

Key Words: *Breast; Carcinoma; Diagnostic imaging; Neoplasms*

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Data Availability: All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics Approval: This retrospective study was approved by the New Territories West Cluster Research Ethics Committee (NTWC/REC/21020). The requirement to obtain written informed consent was waived.

中文摘要

亞洲人群隱匿性乳腺病變的影像學引導定位：磁性粒子和金屬線比較分析

楊思悅、黃于庭、梁宝卉、李安慈、郭啓欣、周朗妍、黎爾德

目的：比較亞洲人群隱匿性乳腺病變的磁性粒子定位和金屬線定位的手術結果。

方法：我們2019年7月至2021年6月期間，對影像學引導下磁性粒子定位或金屬線定位後接受乳腺手術的91名非隨機女性患者進行回顧性分析。比較放置成功率（即標記與病灶距離10 mm以下）、病灶檢出率、標記物回取率和併發症率。

結果：48例患者接受磁性粒子術前定位，43例患者接受金屬線術前定位；標記並切除共100個病灶（磁粒子和金屬線各佔50個）。磁性粒子在術前0至126天放置（中位數14天）；在標記的50個病灶中，22個在同一天進行切除，其餘28個在下一天進行切除。兩組的標記成功率相同，均達98.0%。所有病灶均在第一次手術中發現並成功切除；所有標記物都被完整取回和無併發症。

結論：與傳統金屬線定位比較，磁性粒子定位於亞洲乳房較薄和較緻密患者的手術成功率和安全性相若。它可能是金屬線定位的一個有效替代方法，具有分開病灶定位和手術期的額外優勢。

INTRODUCTION

Accurate preoperative localisation is key to successful surgical excision of nonpalpable breast lesions. Conventional image-guided hookwire localisation (HWL) has been the most commonly used method for decades, owing to its advantages of high accuracy and cost-effectiveness.[1] However, it has several drawbacks, including patient discomfort, potential wire transection, dislocation, and migration due to its protruding external portion.[2] Moreover, because HWL must be performed on the day of surgery, close coordination between surgery and radiology schedules is necessary. In order to uncouple localisation and surgery times, alternative non-wire localisation techniques have subsequently been developed. In 1999, Luini et al[3] first reported on ^{99m}Tc-labelled colloidal albumin-guided occult lesion localisation that can be performed up to 1 day before surgery. In 2001, Gray et al[4] introduced radioactive seed localisation as an effective alternative to wire localisation, and this can be performed up to 5 days before surgery. These techniques have been shown to be non-inferior to HWL.[5-8]

Magnetic seed markers (Magseed; Endomagnetics, Cambridge, United Kingdom) can be deployed in target lesions under mammographic or ultrasound guidance.[9] The advantages of this technique include improved patient experience and mitigation of the risks of wire transection and dislodgment due to the elimination of the external wire component. Radiologists and surgeons can choose the best entry site independently, which can offer better cosmetic outcomes. It also provides a logistical advantage by allowing scheduling flexibility. However, this technique also comes with limitations. The Magseed marker cannot be repositioned once deployed and causes susceptibility artefacts on magnetic resonance imaging.[9] The detectability of the marker is limited by the depth of placement from the skin, and special non-ferromagnetic surgical instruments are required to prevent interference with the signal generated by the Magseed probe in the operating room.[10,11]

Several studies on Magseed localisation have demonstrated satisfactory efficacy and safety in Western populations.[12-14] However, the evidence is still limited in Asian populations, where the breast tissue is generally denser and thinner. Direct comparison between the traditional HWL and Magseed localisation has been rare.[15] To the best of our knowledge, no such comparison has been conducted on an Asian population. Non-wire localisation techniques such as Magseed localisation have been invaluable in view of these logistical constraints. The aim of the present study was to assess the procedural success and safety of Magseed localisation compared with conventional HWL in an Asian population.

METHODS

Study Design and Patient Population

This was a single-institution retrospective review of all symptomatic female patients who underwent preoperative image-guided localisation of nonpalpable breast lesions by either Magseed or hookwire from July 2019 to June 2021. A total of 91 cases with 100 lesions were included. The age ranged from 29 to 82 years. Cases including same-day and decoupled diagnostic excisional biopsies and therapeutic wide local excisions were performed by specialised breast surgeons.

The STROBE reporting guideline was implemented in the preparation of the manuscript.

Localisation Technique

The choice between Magseed localisation or HWL was based on clinical and radiological discussions, taking into account lesion location and scheduling practicability. All localisation procedures were conducted by breast radiologists with ≥8 years of experience in breast imaging under ultrasound or stereotactic guidance; the imaging modality was chosen based on the nature of the lesions.

Hookwires were placed on the day of surgery. The wire was preloaded into a 20-gauge needle. The insertion site was decided by the operating radiologist, and depended on multiple factors, including lesion position and conspicuity on imaging; usually the shortest path from skin to the lesion was chosen. Magseed is a paramagnetic stainless steel pellet containing nickel and measures 5 mm × 1 mm. It becomes detectable by generating a signal when it is temporarily magnetised by a probe (Sentimag; Endomagnetics) that emits an alternating magnetic field. It is preloaded in an 18-gauge needle and can be placed in a lesion at a depth of up to 3 cm from the skin surface. Magseed localisation was performed either in advance or on the day of surgery, depending on scheduling. Seeds were intraoperatively detected by the surgeon using Sentimag. Audible and visible numeric feedback from the detector provided real-time guidance for the surgeon to locate and excise the lesion.

On the day of localisation, the distance between the marker and lesion and the distance between the marker and skin were recorded. These were measured on the modality under which markers were placed. Placement success was defined as a shortest marker-lesion distance of <10 mm in all planes. Post-deployment mammograms in both mediolateral and craniocaudal views were obtained for all cases to establish marker location. If significant Magseed or hookwire migration of >10 mm was observed, the breast radiologist would communicate with the operating surgeon, and an additional hookwire would be inserted to re-localise the lesion.

A specimen radiograph and/or ultrasound image was acquired immediately after surgery to confirm the retrieval of marker and excision of the lesion.

Data Collection

Clinical information, surgical records, and pathology reports were retrieved from the electronic patient record system. Radiological reports, images, and relevant data were reviewed and recorded from PACS, including breast density based on BI-RADS (breast imaging reporting and data system), breast thickness on mammograms in both mediolateral and craniocaudal views, imaging modality used for localisation, nature of lesion, size of lesion measured on ultrasound if visible, marker-lesion distance on post-deployment mammogram or ultrasound and on specimen radiograph or ultrasound, marker-skin distance on post-deployment mammogram or ultrasound, and complications.

Statistical Analysis

Data are presented as frequency (%) for ordinal or categorical variables, mean ± standard deviation for normally distributed variables, and median (interquartile range [IQR]) for non-normally distributed variables. A normality test was conducted for all quantitative variables to test the distribution. Two independent groups of Magseed localisation (Magseed group) and HWL (hookwire group) were analysed for statistically significant differences. The independent-sample *t* test was used to compare normally distributed variables, the Mann-Whitney *U* test for non-normally distributed variables, the Kruskal–Wallis H test for ordinal variables, and the Chi-squared test or Fisher's exact test for categorical variables. All statistical analyses were performed using SPSS (Windows version 27.0; IBM Corp, Armonk [NY], United States) with two-tailed tests and a significance level of 0.05.

RESULTS

All 91 cases with 100 lesions underwent localisation using 99 markers. Forty-eight (52.7%) cases with 50 lesions required 50 Magseeds, and 43 (47.3%) cases with 50 lesions required 49 hookwires. Magseeds were placed 0 to 126 days before surgery (median=14, IQR=0-35). Of the 50 lesions marked by Magseed, 22 (44.0%) were surgically removed the same day and 28 (56.0%) on a

later day. Flow charts of study patients are shown in Figure 1.

Age (52.8 ± 9.95 years Magseed vs. 54.8 ± 9.10 years hookwire, p=0.553) and breast thickness (mediolateral view: 4.6 ± 1.10 cm Magseed vs. 4.8 ± 1.49 cm hookwire, p=0.701; craniocaudal view: 4.2 ± 0.70 cm Magseed vs. 4.5 ± 1.31 cm hookwire, p=0.620) of both groups showed no statistically significant difference. Most of the breast tissue was heterogeneously dense or extremely dense (heterogeneously dense: 64.0% Magseed vs. 63.6% hookwire; extremely dense: 26.0% Magseed vs. 20.5% hookwire); there were only five (10.0%) and seven (15.9%) breasts of scattered fibroglandular density in the Magseed and hookwire groups, respectively, and there was no breast tissue composed of almost entirely fat in either group (p=0.359) [Table 1].

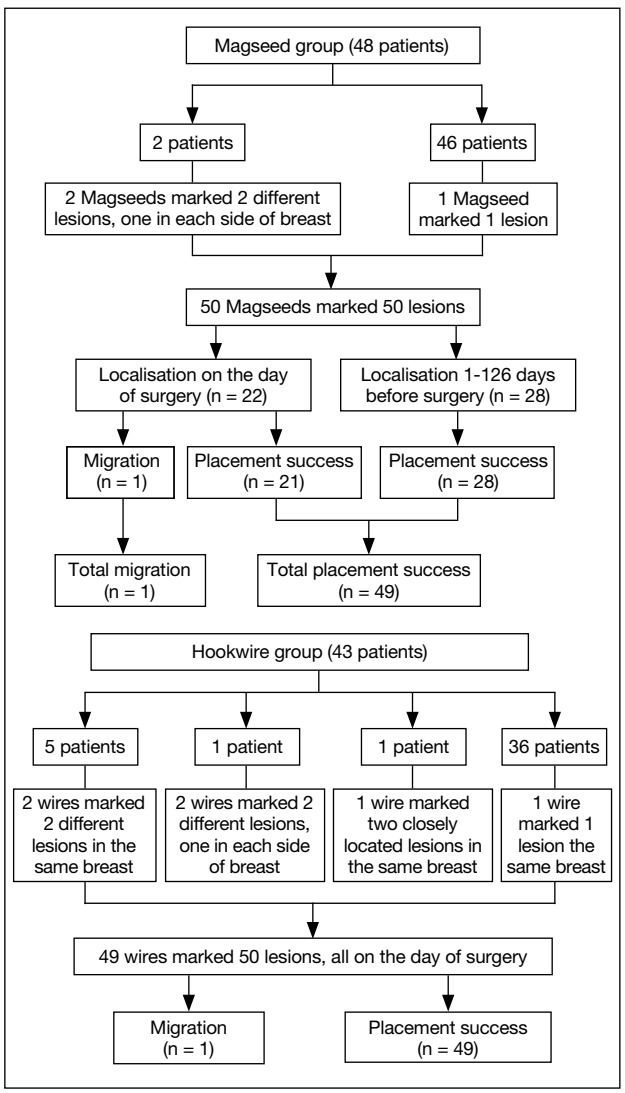

Figure 1. Flowcharts of study patients.

Masses were the most common lesions (62.0% Magseed vs. 74.0% hookwire), followed by microcalcifications (32.0% Magseed vs. 18.0% hookwire), biopsy markers (2.0% Magseed vs. 6.0% hookwire), architectural distortion (2.0% Magseed vs. 2.0% hookwire) and focal asymmetry (2.0% Magseed vs. 0% hookwire). There was no statistically significant difference in the nature of lesion localised for surgery between the two groups (p=0.344). The size of lesions recorded on ultrasound was also statistically comparable in the two groups (median=6.0, IQR=4.3-8.0 for Magseed vs. median=5.5, IQR=4.2-7.0 for hookwire; p=0.365) [Table 1].

In most cases in both groups, ultrasound was the imaging modality used for localisation. Under ultrasound guidance, 62.0% and 78.0% of lesions were marked by Magseed and hookwire, respectively. The rest of the lesions were marked under stereotactic guidance. The modality used for localisation showed no statistically significant difference between the two groups (p=0.081) [Table 2].

The distance between marker and skin, if inserted under ultrasound guidance, ranged from 2 to 18 mm (9.5 ± 4.54) for the Magseed group, and 2 to 19 mm (10.9 ± 3.60) for the hookwire group; if inserted under stereotactic guidance, ranged from 9 to 52 mm (24.8 ± 11.37) for the Magseed group and 13 to 54 mm (31.6 ± 11.40) for the hookwire group. Depth of the marker from the skin was statistically similar between the two groups (p=0.176 ultrasound guidance, p=0.949 stereotactic guidance) [Table 2].

The rate of placement success was statistically comparable between the two groups (98.0% Magseed vs. 98.0% hookwire; p=1.000), under both ultrasound (100% Magseed vs. 97.4% hookwire, p=1.000) and stereotactic guidance (94.7% Magseed vs. 100% hookwire, p=1.000) [Table 2]. Examples of successful Magseed localisation are illustrated in Figures 2 and 3. The only incidence of hookwire migration involved a mass that was localised under ultrasonic guidance. The wire was noted to have been displaced at the post-insertion mammogram. An additional wire was placed to re-localise the lesion. The only migrated Magseed was deployed under stereotactic guidance, which was coupled with a same-day surgery. A subsequent salvage hookwire was placed, and the lesion was then successfully excised (Figure 4). Performance of localisation accuracy and clinical outcomes are summarised in Table 2.

Table 1. Patient demographics, nature and size of lesions stratified by localisation modality.*

	Magseed group (n = 48)	Hookwire group (n = 43)	p Value
No. of lesions (n = 100)	50 (50.0%)	50 (50.0%)	
No. of markers (n = 99)	50 (50.5%)	49 (49.5%)	
Age, y	52.8 ± 9.95	54.8 ± 9.10	0.553
Breast density category			0.359
Almost entirely fatty	0	0	
Scattered area of fibroglandular density	5 (10.0%)	7 (15.9%)	
Heterogeneously dense	32 (64.0%)	28 (63.6%)	
Extremely dense	13 (26.0%)	9 (20.5%)	
Breast thickness on mammogram, cm			
ML view	4.6 ± 1.10	4.8 ± 1.49	0.701
CC view	4.2 ± 0.70	4.5 ± 1.31	0.620
Nature of lesions			0.344
Masses	31 (62.0%)	37 (74.0%)	
Microcalcifications	16 (32.0%)	9 (18.0%)	
Markers	1 (2.0%)	3 (6.0%)	
Architectural distortion	1 (2.0%)	1 (2.0%)	
Focal asymmetry	1 (2.0%)	0	
Size of lesion on ultrasound, median (IQR), mm	6.0 (4.3-8.0)	5.5 (4.2-7.0)	0.365

Abbreviations: CC = craniocaudal; IQR = interquartile range; ML = mediolateral.
* Data are shown as No. (%) or mean ± standard deviation, unless otherwise specified.

Table 2. Localisation accuracy, nature of surgery, clinical and pathologic outcomes stratified by localisation modality.

	Magseed group (n = 48)	Hookwire group (n = 43)	p value
Localisation modality			0.081
Ultrasound	31 (62.0%)	39 (78.0%)	
Stereotaxis	19 (38.0%)	11 (22.0%)	
Marker-skin distance, mm			
On ultrasound	9.5 ± 4.54	10.9 ± 3.60	0.176
On mammogram	24.8 ± 11.37	31.6 ± 11.40	0.949
Marker-lesion distance, median (IQR)	0.0 (0.0-2.5)	0.0 (0.0-0.0)	0.145
<1 mm	38 (76.0%)	43 (86.0%)	
1-5 mm	9 (18.0%)	6 (12.0%)	
6-10 mm	2 (4.0%)	0	
>10 mm	1 (2.0%)	1 (2.0%)	
Placement success	49 (98.0%)	49 (98.0%)	1.000
Under ultrasound guidance	31 (100%)	38 (97.4%)	1.000
Under stereotactic guidance	18 (94.7%)	11 (100%)	1.000
Successful lesion detection at the first operation	50 (100%)	50 (100%)	1.000
Successful transcutaneous detection of marker	50 (100%)	-	
Retrieval success of intact marker	50 (100%)	49 (100%)	1.000
Complications	0	0	1.000
Time interval between localisation and surgery, median (IQR), d	14 (0-35)	0 (0-0)	
Same-day surgery	22 (44.0%)	50 (100%)	
Decoupled surgery	28 (56.0%)	0	
Nature of surgery			0.027
Diagnostic excisional biopsy	49 (98.0%)	43 (86.0%)	
Therapeutic wide local excision	1 (2.0%)	7 (14.0%)	
Surgical pathology			0.991
Malignant lesions	11 (22.0%)	14 (28.0%)	
High-risk lesions	14 (28.0%)	9 (18.0%)	
Benign lesions	25 (50.0%)	27 (54.0%)	

Abbreviation: IQR=interquartile range.
* Data are shown as No. (%) or mean ± standard deviation, unless otherwise specified.

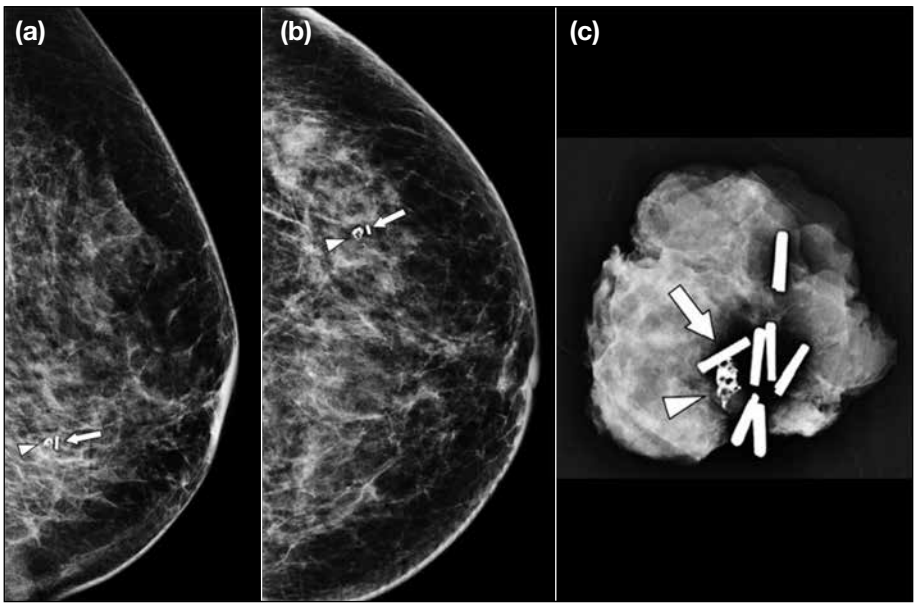

Figure 2. Successful stereotactic-guided Magseed localisation with the surgical specimen. A 70-year-old woman underwent stereotactic-guided Magseed localisation for a cluster of coarse heterogeneous calcifications, which increased in number during follow-up. Magseed was inserted via a lateral-medial approach. Post-deployment mammogram with (a) mediolateral and (b) craniocaudal views confirmed the Magseed (white arrows) was 2 mm from the calcifications (arrowheads). (c) Specimen radiograph confirmed complete removal of the seed and calcifications with accurate marker-lesion distance. Surgical pathology of this case was intraductal papilloma.

Both groups had more excisional biopsies than wide local excision (Magseed: 98.0% vs. 2.0%; hookwire: 86.0% vs. 14.0%). The surgical intent between the two groups showed a statistically significant difference (p=0.027) with the Magseed group more diagnostic excisional biopsies. No significant difference is observed between the two groups in surgical pathology results (p=0.991), with the majority of findings being benign. Details of surgery and pathology are listed in Table 2.

All markers were detected at the first operation and successfully retrieved intact. No unplanned readmission in the window between localisation and surgery was documented for any patients who received decoupled Magseed localisation. No complications were reported. The clinical outcomes are presented in Table 2.

DISCUSSION

Our study demonstrates statistically comparable effectiveness and safety between the Magseed and conventional HWL in an Asian population in terms of placement accuracy, rates of lesion detection, marker retrieval, and complications. To the best of our knowledge, this is the first study directly comparing the performance between Magseed localisation and HWL in Asians.

The Magseed system has been commercially available in the United States since 2016.[10] Price et al[14] published the first study of this technique in 2018, documenting the technical success of accurate marker placement and lesion excision in a North American population. Since then, a growing number of studies have been conducted to provide more evidence of its clinical feasibility in preoperative breast lesion localisation.[12,16,17] The most commonly used localisation technique is still the hookwire, based on the results of a recent national questionnaire about the current practice of nonpalpable breast lesion localisation in the United Kingdom.[18] Although the HWL is still the practice standard, more than half of the centres were dissatisfied with their current localisation technique and had considered changing, the Magseed system being the most commonly stated alternative.[18] The main barriers to change were the higher cost and lack of evidence base of the Magseed system.[18] In Hong Kong, Magseed has only been used since 2019, while HWL remains the most prevalent technique. One pilot study conducted in Hong Kong has provided initial insight into the efficacy and safety of Magseed in in an Asian population.[19] Further robust evaluation of this new method would be vital to support its wider clinical application in Asian populations.

There is currently sparse evidence of direct comparison between hookwire and Magseed pertaining to marker placement accuracy. One abstract published by Micha et al[17] found no difference between them, and the wire/seed marker within 5 mm of the lesion in 96% and

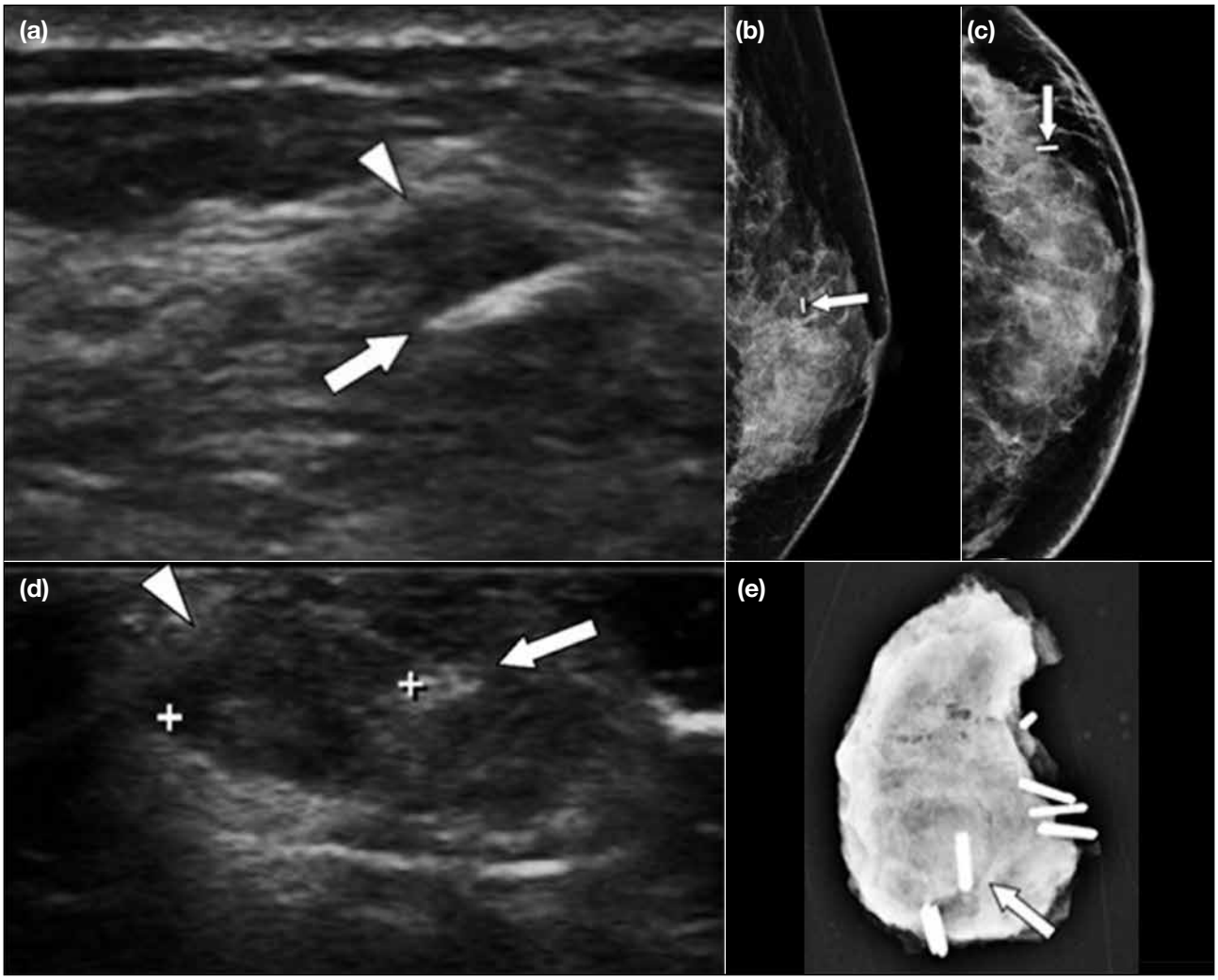

Figure 3. Successful ultrasound guided Magseed localisation with the surgical specimen. A 56-year-old woman underwent ultrasound-guided Magseed localisation for a hypoechoic mass at the 2 o'clock position in the left breast. (a) The Magseed (white arrow) was inserted inside the mass (arrowhead) under ultrasound guidance. Post-deployment mammogram with (b) mediolateral and (c) craniocaudal views confirmed the Magseed (arrows) was in the upper outer quadrant of the left breast. (d) Specimen ultrasound confirmed complete removal of the mass with Magseed inside and (e) specimen radiograph confirmed complete removal of the Magseed. Surgical pathology of this case was intraductal papilloma.

97% of cases, respectively. These results concur with the results of the present study and provide additional evidence for the use of Magseed in Asian populations. In our study, one wire placed under ultrasound guidance migrated after the post-deployment mammogram, and one Magseed migrated after stereotactic-guided localisation for same-day surgery, as shown in Figure 4. The hookwire migration was probably related to inadvertent dislodgement of its external component during mammographic positioning. The Magseed migrated along the direction of the needle track at insertion, which was also observed in one previous study, and the accordion effect is suspected to be the cause of this early migration.[16] Fatty breasts have been found to be susceptible to the accordion effect,[20] and our patients had dense breasts (Table 1), so we hypothesise that there might be a lower risk of early migration in Asian populations. The limitation of seed placement depth of 3 cm is a big challenge for deeply located lesions. Harvey et al[12] concluded that smaller breasts allow easier location of the seed marker during surgery. The median depth of Magseed on post-insertion ultrasound was 16 mm (range, 3.5-30 mm) in their study,[12] compared with a mean depth of 9.5 mm (range, 2-18 mm) in the

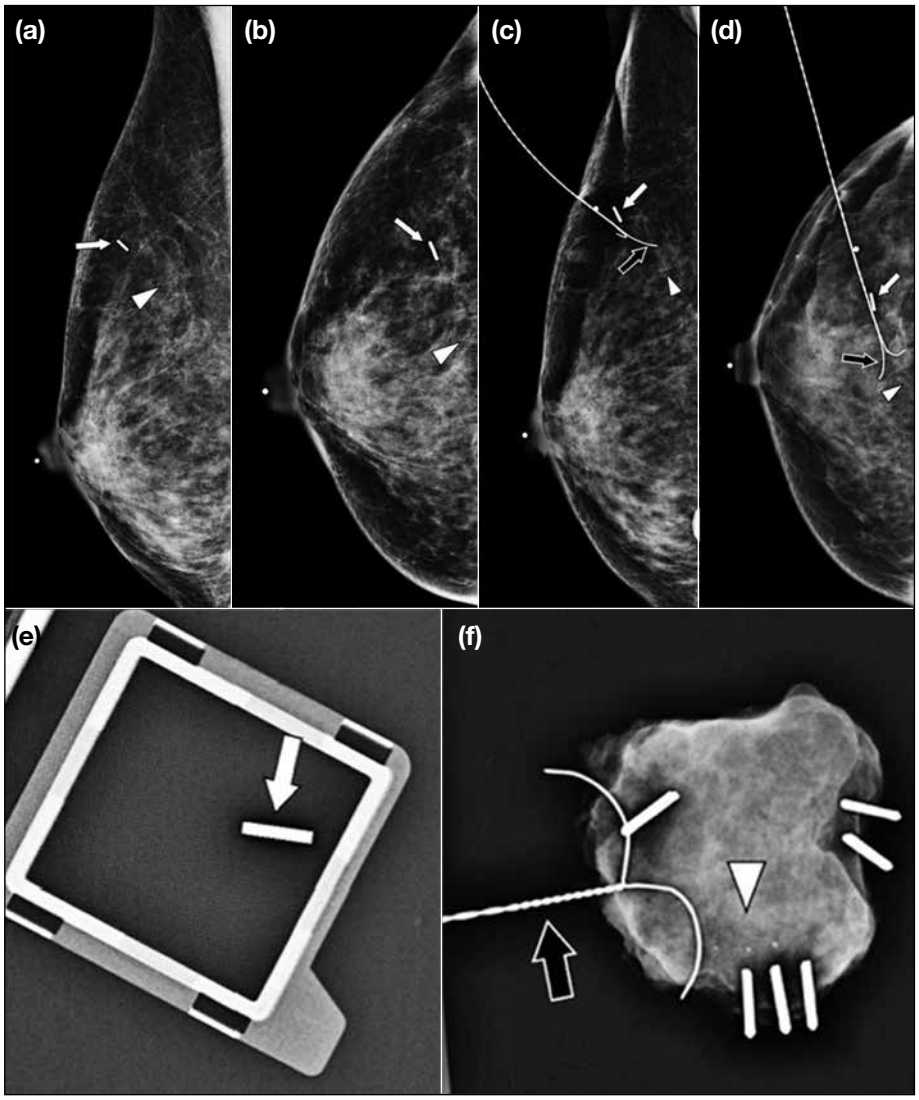

Figure 4. Stereotactic-guided Magseed localisation for a cluster of microcalcifications in the upper outer quadrant of the right breast. The seed was inserted via a lateral-medial approach. Post-deployment mammogram with (a) lateromedial and (b) craniocaudal views found the Magseed (white arrows) migrated >10 mm from the target microcalcifications (arrowheads). Thus, a hookwire (black arrows) was inserted under stereotactic guidance via a lateral-medial approach, and post-deployment mammogram with (c) mediolateral and (d) craniocaudal views confirmed the accurate position of wire with wire-lesion distance measuring 5 mm. (e, f) Specimen radiograph confirmed complete removal of the Magseed, wire and target microcalcifications. Surgical pathology of this case was fibrocystic change.

present study. Given that the lesions were generally superficial in our patients, and breasts are smaller and denser in Asian populations,[21,22] we hypothesise that Magseed is likely to provide more accurate seed localisation and easier surgical excision in Asian populations. Further investigation with larger sample size and collaboration with breast surgeons to review the surgical outcome are needed to verify our hypothesis.

One of the significant merits of Magseed localisation is logistical flexibility. Previous studies have demonstrated the efficacy and safety of decoupled image-guided procedures and surgery.[14,17] Our results are broadly similar; none of the pre-inserted Magseeds migrated and were successfully retrieved, and all the lesions were successfully excised at the first operation without complications (Table 2). These findings are promising, especially under the time and logistical constraints of a pandemic, as Magseed localisation can provide greater scheduling flexibility and efficiency in radiology suite and operating theatre utilisation.

Our study has several limitations. This is a small sample, retrospective, single-institution review, which has inherent selection bias. Firstly, some patients were chosen to have decoupled Magseed placement/surgery instead of HWL due to rescheduling of their surgery dates during the COVID-19 outbreak. Hence, the patient selection was not randomised. Secondly, the surgical intents between the two groups were statistically

significantly different, where wide local excisions were more common in the hookwire group, and diagnostic excisional biopsies were more common in the Magseed group. The differences can be explained by specific logistical arrangements during the COVID-19 pandemic period. First, there was a tendency to proceed with the scheduled HWL and same-day operation for higher priority therapeutic excision of malignant lesions, and diagnostic excisional biopsies of non-malignant cases were more likely to be rescheduled for decoupled operation using the Magseed. Second, during certain time periods, some of the malignant cases were referred out to centres that do not handle suspected or confirmed COVID-19 patients. Thus, nearly all who underwent Magseed localisation and subsequent surgery were those with non-malignant pathology on preoperative biopsies and surgery with diagnostic intent (Table 2). These factors may have potentially generated systematic bias in this study. Based on these objective reasons, we did not investigate and compare the surgical outcomes of Magseed localisation and HWL, which is another limitation. To date, few studies have been conducted for a direct comparison of surgical outcomes between Magseed localisation and HWL. Those performed in European populations observed comparable rates of margin positivity and re-excision,[23,24] but no data are available in Asia. Previously, Walsh et al[25] concluded that higher breast density is associated with higher re-excision rates in women having breast-conserving surgery. Asian populations have denser and smaller breasts[21,22]; therefore, further analysis and comparison of surgical outcomes between Magseed localisation and HWL, including margin positivity, re-excision rate, and specimen weight, would be important to look for additional clinical benefits to justify a change of practice from wire to Magseed localisation.

CONCLUSION

The results of the present study support the use of Magseed localisation as a reliable substitute for conventional HWL in Asian populations. Further investigation of surgical outcomes, prospective multicentre randomised studies with larger sample sizes, and cost-effectiveness studies would be helpful to validate its widespread clinical adoption.

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