



Wired for Surgical Success: Our Experience with Preoperative Ultrasound-Guided Wire Localization of Impalpable Breast Lesions

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Abstract

Aims The purpose of this study was to review our experience with preoperative ultrasound-guided wire localization and to identify our rate of successful localization and subsequent excision.

Materials and Methods At our institution, we performed preoperative wire localization for 28 impalpable breast lesions in 27 women (1 patient underwent wire localization for bilateral breast lesions), between April 2016 and August 2019. We used a Toshiba APLIO2 ultrasound machine and a linear probe (7–12 MHz) to visualize lesions and needle-wire systems comprising a 20-gauge needle with preloaded wire to localize lesions. We analyzed the percentage of specimen mammograms with wire in situ and percentage of excised specimens showing margins free of tumor, along with imaging features, BI-RADS (Breast Imaging-Reporting and Data System) categories, and histopathological and molecular diagnosis of the lesions.

Results All specimen mammograms confirmed the presence of wire in situ, except one (96.4%); in the latter case, postponement of surgery due to intractable cough was suspected to have caused wire displacement. All malignant specimens showed margins free of tumor (100%).

Conclusions Our results show that wire localization is extremely effective in providing crucial preoperative insight into the precise location of an impalpable lesion. Despite the advent of nonwire localization devices such as radioactive seeds, radar reflectors, magnetic seed markers, and radiofrequency identification tags, wire localization remains the most widely practiced method, especially in resource-limited settings. Its high degree of accuracy serves as a key factor in the successful outcome of breast conservation surgery for impalpable breast lesions.

Keywords

- ▶ breast
- ▶ impalpable
- ▶ ultrasound-guided
- ▶ wire localization

Introduction

Nearly half a century has passed since the earliest needle localization techniques and primitive wire models were

developed independently by multiple pioneers including Ferris M Hall, Daniel B Kopans, Marc J Homer, and Norman L Sadowsky, amongst others. Their reflections on the early days of breast imaging, the initial approaches to localization

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of impalpable lesions, the skepticism with which localization techniques were originally received, the pre-existing governmental and corporate structures that hindered its immediate application, and their eventual progress are depicted with sublime beauty in *Boston Remembrances*¹—it makes for wonderful reading. At a time when routine mammographic screening had still not become popular and conventional mammography was cumbersome, owing to time loss in film development, needle localization was often done blindly, without real-time image guidance. Also, needles tailored to specific requirements were difficult to procure.

In recent times, with the advancement in mammography and widespread screening practices, small and clinically impalpable lesions are routinely detected. The exponential advantages of early detection and treatment of breast malignancies have thrown into sharp focus, all options that could potentially facilitate the same. Wire localization is the most well-known of these methods. Although newer devices such as radioactive and magnetic seeds, radar reflectors, and radio-frequency identification tags overcome logistic difficulties of wire localization related to procedure scheduling, other factors such as increased start-up costs, need for radioactivity and related infrastructure, the need for special (in some instances, nonferromagnetic) surgical tools, and the possibility of device migration and allergic reactions to the components of the devices have precluded the widespread use of these newer devices.² Consequently, wire localization, as an accurate, cost-effective and widely accessible technique, continues to enjoy immense popularity. Our study aimed to review our experience with ultrasound-guided wire localization techniques and to identify our rate of successful localization and subsequent excision.

Materials and Methods

In our department, preoperative wire localization was performed for 28 impalpable breast lesions in 27 women (1 patient underwent wire localization for bilateral breast lesions), between April 2016 and August 2019, after explaining the procedure and obtaining informed consent. The lesions had been diagnosed either during regular screening or while under evaluation for other breast complaints.

Materials: Lesions were visualized using a Toshiba APLIO2 machine and a linear probe (7–12 MHz). The localization devices we employed composed of a 20-gauge needle with a preloaded wire. Diagrammatic representations and photographs of the needle, the wire, and the needle with preloaded wire are shown in (►Fig. 1). We used wires with different hooks (►Fig. 2), including the single straight, double curved, and double straight types.

Procedure: With the patient in the supine position, and ipsilateral arm abducted and placed above the head (as shown in ►Fig. 3), ultrasound of the breast is done to visualize the lesion.

A diagrammatic representation of the procedure is shown in ►Fig. 4. To localize the lesion, the needle with preloaded wire is first reached up to and then pushed through the lesion so that the needle tip is just beyond the lesion.

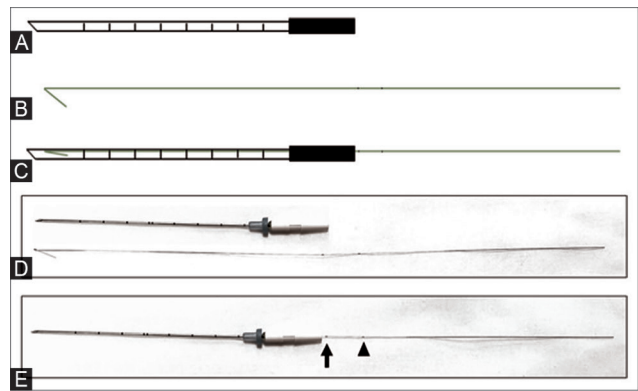


Fig. 1 (A–E) Diagram of the (A) outer needle, (B) hook wire, and (C) hook-wire preloaded into the needle. Images of (D) needle (above) and hook wire (below), and (E) needle with preloaded wire. The wire is initially loaded into the needle till the first marking (black arrow); while deploying the wire, it is advanced till the second marking (arrowhead).



Fig. 2 (A–C) Different hook types. (A) straight single hook, (B) curved double hook, (C) straight double hook.



Fig. 3 Patient positioning during the procedure: supine, with the ipsilateral arm abducted and placed above the head. In this postlocalization image, the outer needle has been withdrawn and the external portion of the deployed wire is seen.

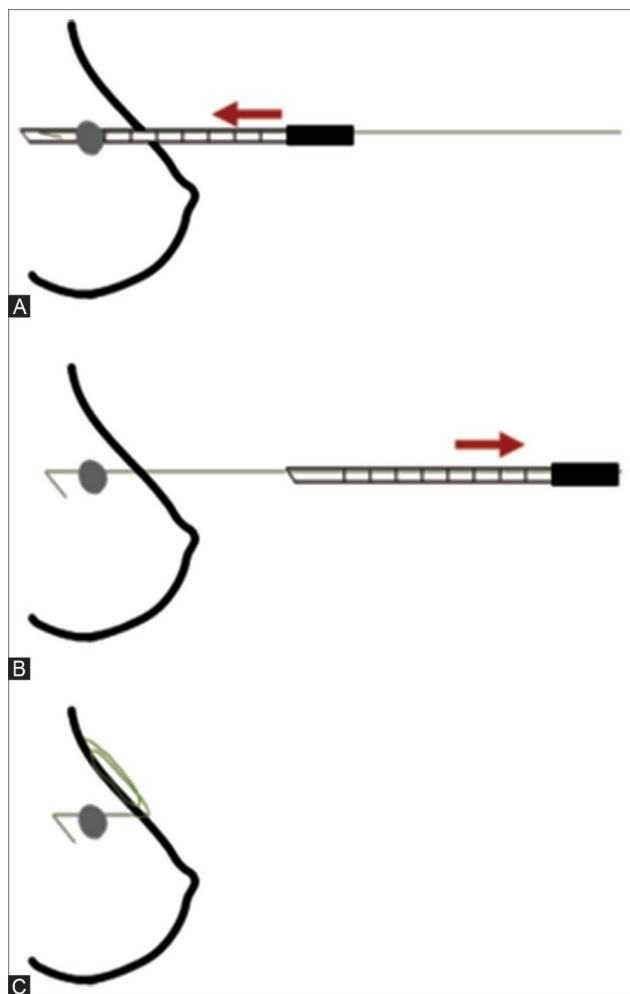


Fig. 4 (A–C) Diagram of wire localization procedure. (A) First, the needle with preloaded wire is pushed through such that it is just beyond the lesion. (B) Next, hook wire is advanced beyond the needle verge till the second marking and simultaneously outer needle is withdrawn. Tip of hook wire reforms within the breast and anchors onto the lesion. (C) Then, the external part of the flexible wire is secured onto the skin and the patient is shifted to the operating room.

The hook wire is advanced beyond the needle verge till the second marking and simultaneously the outer needle is withdrawn. The tip of the hook wire reforms, causing the wire to anchor onto the lesion and remain in place. The hook wire is then gently tugged upon to confirm that it is safely anchored in. The external part of the wire is then secured on the skin, with sterile gauze and micropore, in such a way that an unobstructed view of the position of the hook in relation to the lesion is obtained on the check mammogram, which is to follow immediately.

Once the check mammogram is taken in craniocaudal and mediolateral oblique views to confirm the position of the hook wire, the patient, with the wire in situ, is shifted directly to the operating room, along with the check X-ray mammogram. Postoperatively, a specimen radiograph is obtained for the lesion, before sending the specimen for histopathological examination. The routine set of radiological images includes the initial mammogram and breast

ultrasound, the ultrasound image during the localization procedure documenting the hook wire within the lesion, the check mammogram (mediolateral oblique and craniocaudal views), and the specimen radiograph. A case-based example is shown in ► **Fig. 5**.

Histopathological analysis was done at the Department of Pathology in our institution. For the 28 localized lesions, we retrospectively analyzed the following: (1) the percentage of specimen mammograms which showed the presence of the wire in situ, (2) the percentage of specimens with margins free of tumor, (3) the location of the lesions in terms of laterality and breast quadrants, (4) the mammographic and ultrasonographic features that were initially observed, (5) the reported BI-RADS (Breast Imaging-Reporting and Data System) classification, (6) the final histopathological diagnosis, and, (7) molecular diagnosis of the malignant lesions.

Results

In total, 27 patients between 32 and 74 years of age (mean age: 50.3 ± 23.7) underwent wire localization. The mean age of patients with malignant disease was 57.6 years (range: 40–74 years) and the mean age of patients with benign disease was 46.0 years (range: 32–74 years). The age distribution of patients with benign and malignant lesions is depicted in ► **Fig. 6**.

Of the 28 lesions for which wire localization was done, 13 were in the right breast and 15 were in the left breast. A total of 17 lesions were found in the upper outer quadrant,

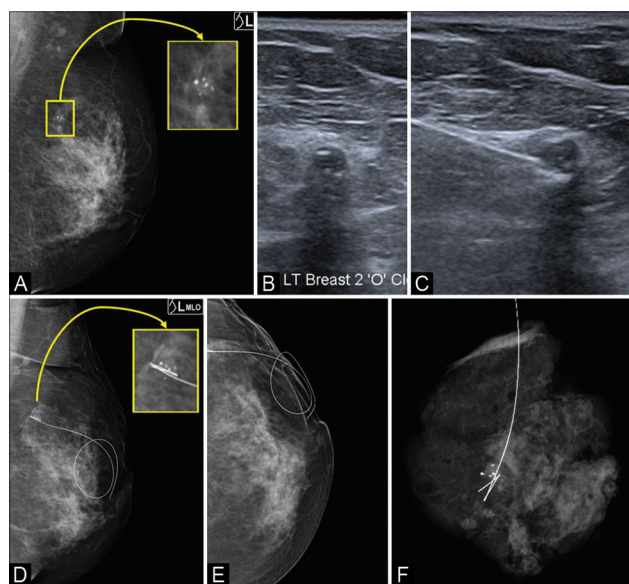


Fig. 5 (A–F) During regular screening of a 63-year-old lady with a family history of breast carcinoma, (A) mammogram showed grouped amorphous calcifications, (B) on ultrasound a small well-defined oval circumscribed hypoechoic lesion with posterior acoustic shadowing and few calcific specks was seen, (C) post-localization, the hook wire is seen anchoring the lesion. The (D) MLO and (E) CC views of the check mammogram and (F) postoperative specimen radiograph show the wire in close proximity to the calcifications. It was proven to be predominantly DCIS with a focus of invasion. CC, craniocaudal; DCIS, ductal carcinoma in situ; MLO, mediolateral oblique.

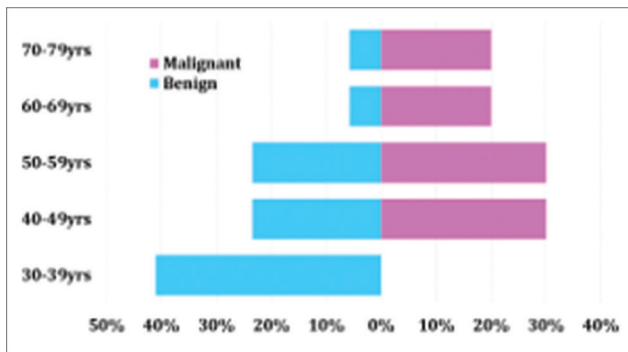


Fig. 6 Age distribution of the patients who underwent wire localization. The number of patients and the age of the patients are plotted along the x- and y-axes, respectively. The patients with benign lesions (blue) and malignant lesions (pink) are shown to the left and right of the midline, respectively.

7 lesions were found in the upper inner quadrant, one each in the lower inner and lower outer quadrants, and 2 in the subareolar region.

Core biopsies were performed prior to localization for all the lesions; benign lesions were excised in view of patient preference.

On ultrasound examination, 25 were mass lesions, of which 7 were malignant (25%). In the other three cases, no obvious mass was seen on ultrasound; these presented as heterogeneous parenchyma with adjacent ductal dilatation. All three lesions were subsequently proven malignant (100%).

At our institution, mammogram is done for patients above 40 years, unless a younger patient with risk factors specifically wishes to have a mammogram done. A mammogram was done in our institution for 24 patients (25 lesions). Mammogram of the 25 lesions revealed mass alone in 48% ($n = 12$), mass with suspicious calcifications in 28% ($n = 7$), and suspicious calcifications with no obvious mass in 24% ($n = 6$). For three patients, mammogram was not done due to young age. All three lesions were benign.

BI-RADS distribution (depicted in ►Fig. 7) was as follows: BI-RADS 2 ($n = 2$), BI-RADS 3 ($n = 5$), BI-RADS 4 ($n = 14$), and BI-RADS 5 ($n = 7$).

For the two lesions categorized as BI-RADS 2, wire localizations were done in view of patient concern owing to previous history of squamous cell carcinoma in the contralateral breast in one patient and strong family history of breast cancer in the other patient. The lesions proved to be fibrocystic disease with sclerosing adenosis and fibroadenoma, respectively.

Among 5 lesions categorized as BI-RADS 3, 3 were fibrocystic disease, 1 was benign ductal papilloma, and 1 lesion was invasive carcinoma (it was predominantly ductal carcinoma in situ, with a small focus of invasion).

Of the 14 lesions categorized as BI-RADS 4, histopathology revealed 4 invasive carcinomas, 1 ductal carcinoma in situ, 4 phyllodes tumors, and 1 each of fibroadenoma, benign ductal papilloma, pseudo-angiomatous stromal hyperplasia (PASH), chronic mastitis with duct ectasia, and lymphocytic lobulitis.

Of the seven lesions which were categorized as BI-RADS 5, two were proven to be invasive carcinomas and two were ductal carcinomas in situ. The remaining three proved to be

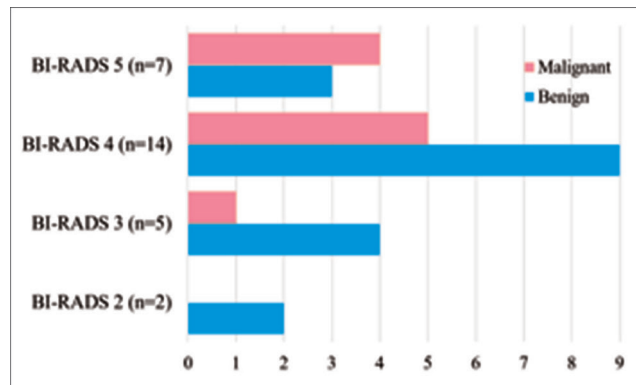


Fig. 7 The BI-RADS distribution of the benign (blue) and malignant (pink) lesions.

one each of phyllodes tumor, benign ductal papilloma, and pseudo-angiomatous stromal hyperplasia.

In summary, 10/28 (35.7%) lesions were malignant and 18/28 (64.3%) lesions were benign. As depicted in (►Fig. 8), the 10 malignant lesions composed of 3 ductal carcinomas in situ (1 low grade and 2 high grade) and 7 invasive carcinomas (5 were Nottingham grade 1, while the other two lesions were grades 2 and 3). Molecular and hormonal status analysis of the 7 invasive lesions showed that 3 were luminal B subtype, 1 was luminal A subtype, and 3 were found to have Her 2 positivity. Of the Her 2-positive lesions, two were also found to have EGFR (epidermal growth factor receptor) positivity.

The 18 benign lesions composed of 5 phyllodes tumors, 3 papillomas, 2 pseudo-angiomatous stromal hyperplasia, 3 fibrocystic lesions with associated papillomatosis/sclerosing changes, 3 fibroadenomas, 1 chronic mastopathy with duct ectasia, and 1 lymphocytic lobulitis (►Fig. 9).

All but one specimen mammograms confirmed the presence of wire in situ (96.4%). In the latter case, the patient had developed an intractable cough. The surgery was postponed. The delay and the cough probably resulted in the displacement of the wire. All malignant specimens showed margins free of tumor (100%).

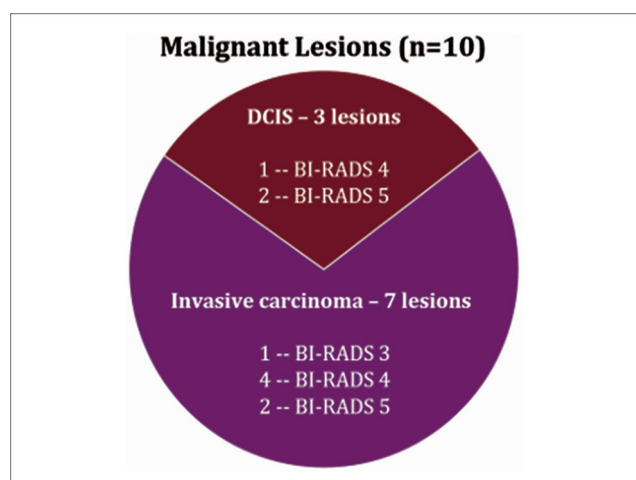


Fig. 8 The histopathological diagnoses of the malignant lesions and their BI-RADS categories.

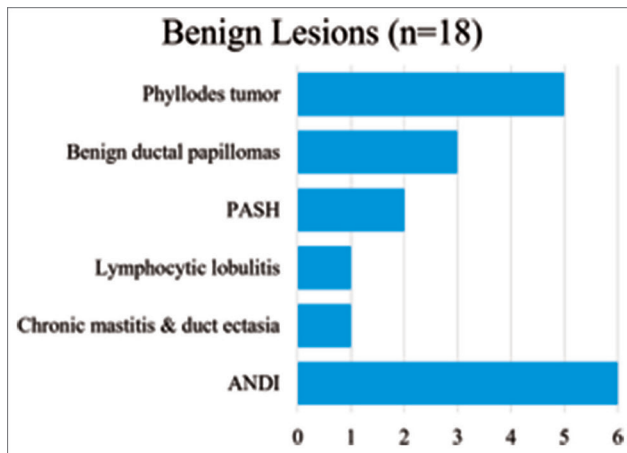


Fig. 9 The histopathological diagnoses of lesions that were eventually proven benign. ANDI, aberrations of normal development and involution; PASH, pseudo-angiomatous stromal hyperplasia.

Discussion

Preoperative wire localization is a technique by which a wire is passed through an impalpable lesion, to enable its easy identification by the operating surgeon. Thus, preoperative localization acts as an effective guide during breast conservation surgery (BCS), enabling surgeons to minimize the volume of normal tissue that is excised. Accuracy in localization is the crucial factor that has a profound bearing on the results of BCS.

Decades ago, local excisions and biopsies were done blindly after mammogram.³ The earliest localization techniques were noninvasive and employed radio-opaque skin surface markers. The distance of the lesion from the surface marker on a mammogram would guide excision. Invasive localization techniques, introduced in the late 1970s, greatly improved the accuracy of localization and consequently the success rates of wide local excision. The earliest of these was the blind insertion of needles after a mammogram. Subsequent check mammograms would be used to determine the distance of the needle from the lesion and its position relative to the lesion. Another method was the dye injection (spot) localization technique. In this method, after inserting the needle, a mammogram was taken to ascertain its proximity to the lesion. The needle position was readjusted if needed. After ensuring the desired needle position, a dye and contrast medium were injected via the needle, and then the needle was withdrawn. The contrast agent would be seen on the check mammogram and the patient sent to the operating room. The dye would guide the surgeon visually while excising the lesion. However, the drawback of this method was the potential of the dye to disperse within the breast parenchyma and into the ducts, which necessitated immediate availability of the operating room, to excise the lesion before the dispersion could occur.

Subsequently, needle localization began to be performed under real-time ultrasound guidance. However, the needles could become displaced or dislodged during the interval between localization and excision.

Hook-wire systems, made of self-retaining flexible wires, were developed to overcome the possibility of needle displacement. Variations, including the spring hook, curved

wire, and double hooked wire, were developed subsequently to provide greater stability of the wire in the breast and to further reduce the chances of wire displacement.⁴ At present, hook-wire systems are widely used in the localization of impalpable breast lesions. Their affordability, accessibility, and accuracy are key factors that propel their continued use in clinical practice.

For any procedure, a periodic review of procedural results paves the way for improved outcomes. An analysis of our results and comparison of outcomes with previously published studies is presented below.

In an audit to analyze their localization outcomes, Mucci et al⁵ reported their accuracy in localizing 251 lesions under ultrasound guidance to be 97%, considering a 5 mm margin.

Of 83 patients for whom Yuan et al⁶ had performed localization procedures, 32 were under ultrasound guidance. On analyzing their outcomes, they found that 94% of lesions had been accurately localized.

Another study by Jakimovska Dimitrovska et al,⁷ in which lesions were localized either by mammographic or ultrasound guidance, reported that overall, in 97% of cases the wire crossed the lesion.

Das et al⁸ reported their outcomes in needle and wire localizing 22 lesions by ultrasound guidance. Specimen mammogram had been done in 18 of 22 specimens, all of which found the lesion was accurately resected. They reported dislodgement of the needle in one of the other four cases. Their overall accuracy rate was 95%.

Shetty⁹ reported a 1% rate of failure to excise, among 202 wire localization procedures. He concluded that failed excision was due to the displacement of the wire while shifting the patient to the operating room.

In our study, all but one specimen mammogram confirmed the presence of wire in situ (96.4%) and all malignant specimens showed margins free of tumor (100%). Our results are comparable to existing literature.

Benign lesions that were wire localized comprised predominantly of phyllodes tumors, pseudo-angiomatous stromal hyperplasia, benign duct papilloma, and lymphocytic lobulitis—all well-described mimics of malignancy. Representative cases are shown in ►Figs. 10 and 11.

Possible, albeit rare, complications of wire localization include¹⁰:

- Vasovagal episodes.
- Transection of the needle.
- Fraying of the needle after deployment.
- Pneumothorax and pericardial injuries due to migration of wire into the pleural and pericardial space, respectively.
- Risk of diathermy injury to the skin during excision.
- Cosmetic inferiority when compared with nonwire localization techniques.

A major drawback of wire localization from a logistic viewpoint is the degree of coordination in scheduling required between the radiology out-patient department and the operating room, since lesion must be excised as soon as possible after localization, to decrease the chances of wire dislodgement and migration, as well as to reduce patient discomfort.

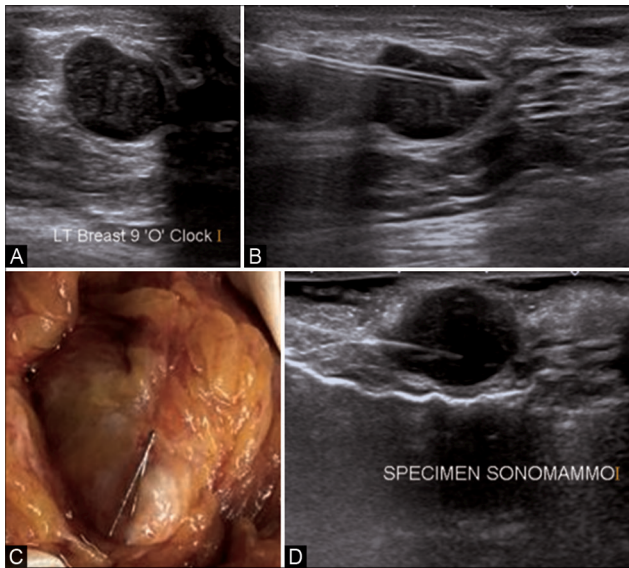


Fig. 10 (A–D) A 32-year-old patient presented with a lump in the right breast. (A) Ultrasound incidentally showed a well-defined round heteroechoic lesion, with posterior acoustic enhancement in the left breast, which was wire-localized under ultrasound guidance. (B) Hook-wire anchoring the lesion. (C) Excised gross specimen with hook wire in situ. (D) Postoperative specimen sonogram with wire in situ. It was a benign ductal papilloma.

Apart from the widely practiced ultrasound-guided single wire localization technique that we have used, other wire localization techniques include wire localization under stereotactic guidance and the use of multiple “bracketing” wires for lesions that require larger areas of resection.¹¹

The primary driving force for the development of nonwire localization devices is to overcome the scheduling constraints associated with wire localization. The common advantages and disadvantages of various nonwire localization devices are given below.

Common Advantages

- Decreased scheduling constraints since the devices can remain in situ for a longer time.
- Continuous intraoperative “re-centering” of the tumor using the hand-held probe increases the accuracy of resection.
- Decreased procedure time.¹⁰
- Decreased hospital stay.¹⁰
- Better cosmesis.¹⁰

Common Disadvantages

- Cost of the initial investment in the reusable console and probe.
- Cost of the localization devices.
- Nonrepositionable nature—if the device is incorrectly positioned, a second device is needed.

Ease of technique and less pain with nonwire devices compared with wire localization have been reported in some studies conducted in Europe.¹⁰

The permissible time between localization and excision for the nonwire devices and specific caveats in their use are described in ► **Table 1**.

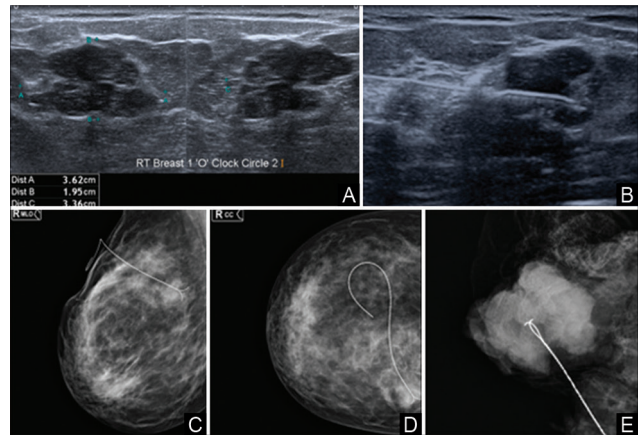


Fig. 11 (A–E) During regular screening of a 37-year-old with a positive family history, mammogram showed posteriorly placed lesions. On ultrasound, irregular hypoechoic lesions were seen in bilateral breasts and wire-localized. It was bilateral phyllodes tumor. The (A) ultrasound image, (B) wire localization image, (C) MLO, and (D) CC views of the check mammogram and (E) specimen radiograph of the lesion in the right breast are shown. CC, craniocaudal; MLO, mediolateral oblique.

Table 1 Nonwire localization devices: permissible time between localization and excision and specific caveats in their use

Name of device	Permissible time b/w localization and surgery	Disadvantages
Radioactive seeds	5 days	<ul style="list-style-type: none"> • Infrastructure for use of radioactivity must be developed, including legal and safety considerations and training of personnel^{2,12} • Loss of a radioactive seed is a reportable medical event • A migrated radioactive seed must be retrieved and cannot be left within the breast
Magnetic seed markers	>30 days	<ul style="list-style-type: none"> • Cannot be used in patients with pacemakers or implanted chest-wall device Requirement for nonferromagnetic surgical instruments, since ferromagnetic instruments will interfere with signal • MRI susceptibility artifact
Radar reflectors	>30 days	<ul style="list-style-type: none"> • Reflector migration • Lack of signal from reflector can occur • Potential for allergic reaction due to nitinol present in antenna of the device • Difficult to place radiologically and trace during surgery if deep to a hematoma^{2,13}
Radio-frequency identification tags (RFIDs)	>30 days	<ul style="list-style-type: none"> • Tag migration (recently antimigratory sheath has been added to the device to overcome this)

One of the nonwire localization methods that do not involve a specific device is the intratumoral radiotracer injection. In this method, a tracer is used to localize the lesion. In this method, the maximum localization to procedure time is 24 hours and lymphatic mapping can be done simultaneously by simultaneously injecting a low-molecular-weight colloid that can migrate to the axilla.¹⁰ Still newer techniques are being explored in the management of impalpable lesions, such as vacuum-assisted biopsy and fiber-optic ductoscopy.⁶

Conclusion

Wire localization under ultrasound guidance provides crucial preoperative insight into the precise location of an impalpable lesion. In the era of newer nonwire localization techniques, we wish to reiterate the continued relevance of wire localization, particularly in resource-limited countries, where there is a discrepancy between the state-of-the-art technology found in a few cities and the small surgical facilities seen in suburban areas. These smaller facilities also cater to the nearby rural populations, which we cannot leave behind. Until a time when the newer devices are universally affordable and widely accessible, the cost-effective wire localization technique remains a strong bridge for us to offer the option of BCS to women with breast disease in suburban and rural areas. Our results emphasize that wire localization enables extremely accurate results in BCS, with the important advantage of requiring less infrastructure.

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Nil.

Conflicts of Interest

There are no conflicts of interest.

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