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Step by Step: Planning A Needle Localization Procedure

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Abstract

In patients with nonpalpable early-stage breast cancer eligible for breast conservation surgery (BCS), wire-guided localization (WGL) is widely accepted as a standard technique for preoperative image-guided lesion localization. In preparation for this procedure, lesion location, size, type and configuration play important roles in preoperative localization planning. Successful preoperative planning requires review of all pertinent imaging studies, imaging reports and pathology reports, with special attention to pre- and post-biopsy imaging and evaluation of the targeted lesions and the type and the position of the marker clips. Preoperative communication with the surgeon is key in the planning process to ensure that clarity in localization objectives are reached in complex cases. This pictorial essay will provide a methodical, step by step approach to planning successful image-guided preoperative needle localizations. These steps include selection of the imaging modality, the equipment, the procedure and intraoperative specimen radiography. The case-based review will also include key steps and considerations during the planning stage, the procedure stage, and the post-procedure stage. These same techniques can also be applied to newer, non-wire image-guided breast localization techniques now available for widespread commercial use.

Keywords

Wire-guided localization; Needle localization; Ultrasound-guided needle localization; Mammography-guided needle localization; Specimen radiography

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Introduction

The number of nonpalpable early-stage breast cancers in the United States continues to increase each year. A significant proportion of this increase can be attributed to the improved utilization of and the ongoing technical advances achieved by screening mammography [1,2]. Breast-conservation therapy (BCS) has become the preferred treatment for patients with early-stage breast cancer, as randomized trials have shown that BCS with adjuvant radiotherapy with or without chemotherapy provides equivalent survival rates when compared with mastectomy in similar patient populations [3].

In patients with nonpalpable early-stage breast cancer eligible for breast conservation surgery (BCS), wire-guided localization (WGL) is widely accepted as a standard technique for preoperative image-guided lesion localization. More recently, new non-wire guided techniques have become available for preoperative localization. These include the use of radioactive iodine-131 seeds, electromagnetic radar reflectors, radiofrequency identification, and magnetic seed technology [4]. The general concepts and considerations covered in this pictorial essay can be applied to most image-guided breast localizations regardless of the device used.

This pictorial essay will provide a methodical, step by step, approach to planning a successful image-guided preoperative needle localization. The case-based review will include key steps and considerations during the planning stage, the procedure stage, and the post-procedure stage. We aim to engage practicing radiologists who can use this methodology to improve preoperative localization planning and drive local changes that can improve patient care.

Step 1: Selection of the Imaging Modality

In preparation for the procedure, lesion size, type and configuration play an important role in preoperative localization planning. Successful preoperative planning also requires review of all pertinent imaging studies, imaging reports and pathology reports with special attention to pre- and post-biopsy imaging and evaluation of the targeted lesions and the type and the position of the marker clips. Preoperative communication with the surgeon is key in the planning process to ensure that clarity in the localization objectives are reached in complex cases.

There are a number of factors that should be considered when determining the modality of choice for preoperative localization (Figure 1). When reviewing the case, all relevant imaging studies should be readily available for review. The radiologist should note the association of the targeted lesion with calcifications, the lesion span, a prior history of neoadjuvant chemotherapy, as well as the location of the post-biopsy clip(s) relative to the targeted lesion(s). If there is a history of neoadjuvant therapy, review of multimodality pre-therapy imaging is key in determining the presumed tumor bed (footprint of the residual disease). While MRI is usually the imaging modality of choice to monitor neoadjuvant therapy response, localization under mammography or ultrasound guidance is usually preferred. In these cases, using mammographic landmarks and the location of the clip markers with respect to residual enhancement helps to determine the scope of the pre-

operative localization and guide surgical excision. In a small study (n = 29) of cancers that initially presented as microcalcifications treated with neoadjuvant chemotherapy, residual microcalcifications were associated with residual tumor in 55.2% of cases [5]. Though the actual extent of residual calcifications has been in some situations shown not to correlate histopathologically with residual disease, complete excision of tumor bed calcifications remains standard practice until additional studies better define which histologic and biologic patient subpopulations may be candidates for more conservative treatment. Therefore, the localized tumor bed should include any visible calcifications in these cases regardless of the degree of response on ultrasound or MRI.

Contrast-enhanced spectral mammography [CESM] is increasingly used in breast cancer extent of disease evaluation [6]. For additional lesions identified on CESM alone, the patients are usually referred to breast MRI for biopsy or needle localization. If a contraindication to MRI exists, low-energy CESM can be used to localize the area using mammographic landmarks. CT guided localization may be performed on biopsy proven metastatic axillary nodes with metallic clips which are not seen on ultrasound following neoadjuvant therapy.

In a small population of patients with nipple discharge, intraductal lesions identified on ductography may warrant ductography-guided needle localization to help ensure that the correct discharging duct is removed. In these cases, methylene blue is also frequently injected within the discharging duct to enhance the visibility of the ductal system intraoperatively.

Having the following general rules can aid in the selection of the imaging modality. If the lesion is readily identified on ultrasound, consider ultrasound first due to the ease of patient positioning and targeting. If one or more of the lesions are better visualized on mammography, consider mammographic guidance for targeting all lesions. One may need to consider tomosynthesis or stereotactic targeting for lesions seen on only one view. Figure 1 helps to delineate these considerations pictorially.

Step 2: The Equipment

Just as important as determining the imaging modality for localization, the radiologist needs to ensure that the proper equipment is available for the localization procedure. At a minimum, the radiologist will need local anesthetic (commonly 1% of 2% lidocaine HCL at a 10mg/mL concentration), a skin sterilization agent such as chlorohexidine or iodine, a 5-10 mL syringe with a needle for anesthetizing the skin, and a localization needle with a pre-loaded wire (Figure 2A).8.5% sodium bicarbonate can also be used as a buffering agent to decrease the pain of injection. There are a number of factors that also play a role in determining the type and the number of needles for localization, as depicted in Figures 2B and 2C. The Kopans wire is the most widely used hook wire in practice, ranging in size from 3-15 cm. MRI compatible wires are also available. Similarly, the Hawkins wire is a braided hook wire with common use in women with dense breasts and ranges in size from 3 to 12.5 cm. The Homer or “J” shaped memory wire ranges in size from 3-12.5 cm and is best known for its retractibility after placement.

When selecting wire length for a mammography-guided needle localization, the location of the lesion helps best determine the approach and the wire length. The shortest distance from the overlying skin to the lesion should be the primary consideration, provided that the approach does not result in the wire traversing other malignant or suspicious lesions. In instances where this is a potential scenario, an alternative approach should be selected. As a general rule, the length of the needle should always exceed the distance from the lesion to the overlying skin using the designated approach.

Step 3: The Procedure Itself

The steps required for localization are largely dependent on the modality that is being used. Both mammography and ultrasound account for the majority of wire-guided localizations as lesions are most readily detected, biopsied and diagnosed using these two modalities. Larger lesions, calcifications and calcifications with spans exceeding the mass borders frequently require mammographic guidance and multiple needles for bracketing. When using multiple needles to bracket lesions, the anterior, medial and lateral borders should be prioritized. In many cases, the pectoralis fascia can be used as an anatomic border and does not require a separate needle. Communication with the surgeon is key in decision making for larger lesions and complex cases.

During the placement of a non-retractable wire, the radiologist has the option of leaving the wire pre-loaded in the needle hub or unsheathing it at deployment. The radiologist should discuss these options with the surgeon pre-procedurally. Figures 3A and 3B depict the stepwise procedural components for mammography-guided and ultrasound-guided localization, respectively.

Some facilities offer a “beaded” wire containing three beads or a thickened portion that demarcates the last three centimeters. The surgeon can use this as an indication to start cutting. Therefore, the wire should be placed roughly 1 cm past the targeted lesion to ensure that the lesion is centered at the second bead which should reside in the middle of the excised specimen.

Step 4: Specimen Radiography

Intraoperative margin assessment requires multidisciplinary collaboration between surgeons, pathologists and radiologists. Surgeons may use differing methods for specimen orientation, which may involve denotation with surgical clips, long and short suture lengths and charms. It is important that the radiologist familiarize themselves with the surgeon’s practice.

Many surgical practices now utilize specimen radiography units within the operating room to eliminate the time involved in transporting the specimen to the mammography suite. A minimum of two orthogonal images should be obtained to improve margin assessment. At our institution, the en-bloc specimen is radiographed to identify the targeted lesion and then inked to identify orientation of the superior, inferior, lateral, medial, anterior and posterior margins. The specimen is then sectioned into 3 – 5 mm slices by the pathologist. At our institution, the radiologist reviews the images to verify complete local excision of the lesion and the location of the lesion relative to the margins and discusses the findings with the surgeon and/or the pathologist.

In 2014, the American Society for Radiation Oncology (ASTRO) and the Society of Surgical Oncology (SSO) issued a consensus guideline defining an adequate margin for invasive breast cancer as the absence of tumor at the actual edge of the resected tissue ("no ink on tumor") [7]. Though not widely utilized, several studies have shown that intraoperative margin assessment by gross pathological examination and sliced specimen radiography significantly impacts intraoperative decision making, and excision of further tissue on the basis of intraoperative assessment results in a substantial decrease in re-excision surgeries for margin control. At our institution, multidisciplinary intraoperative specimen radiography assessment has assisted in reducing re-excision rates after breast conservation surgery from 21% to 7% [8].

Conclusion

In summary, careful review of pre-operative imaging is warranted to determine the optimal modality for a breast localization procedures. Pre- and post-localization communication with the surgeon is key to maximizing chances of success and negative final margins. Post-localization, the approach and the final position of the localizing needle(s) should be relayed to the surgeon through well-annotated mammograms as well as a diagram depicting the needle positions.

Acknowledgments

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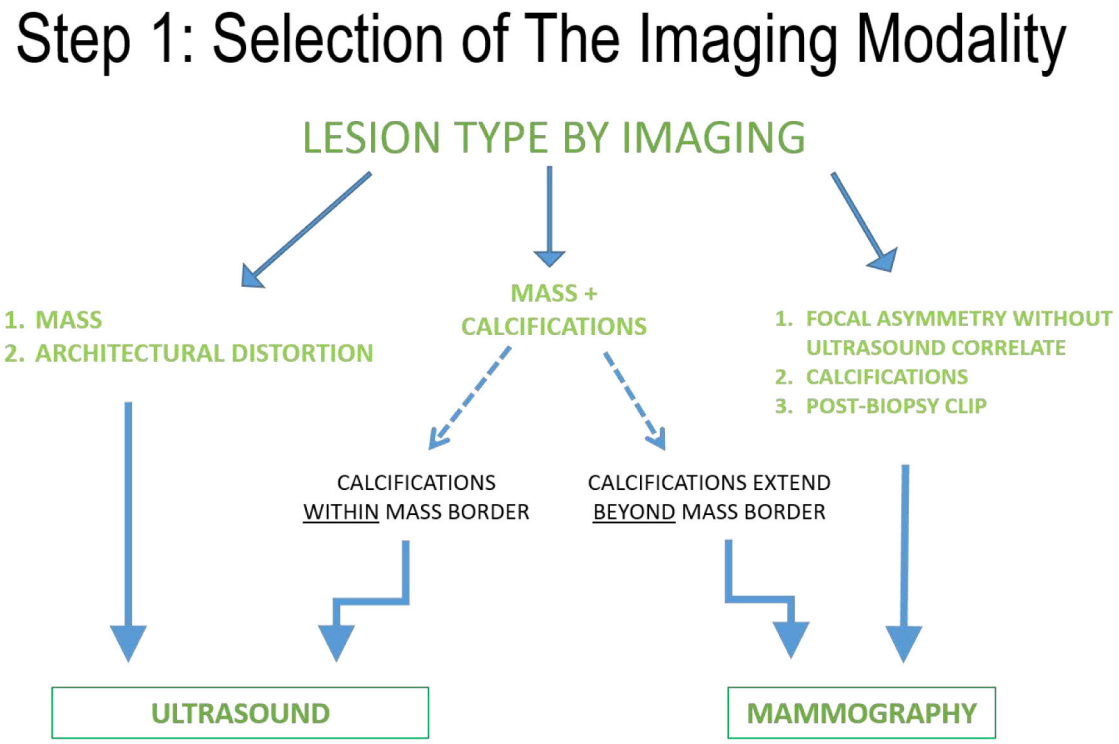


FIGURE 1.

The above factors should be considered when determining the modality of choice for preoperative breast localization.

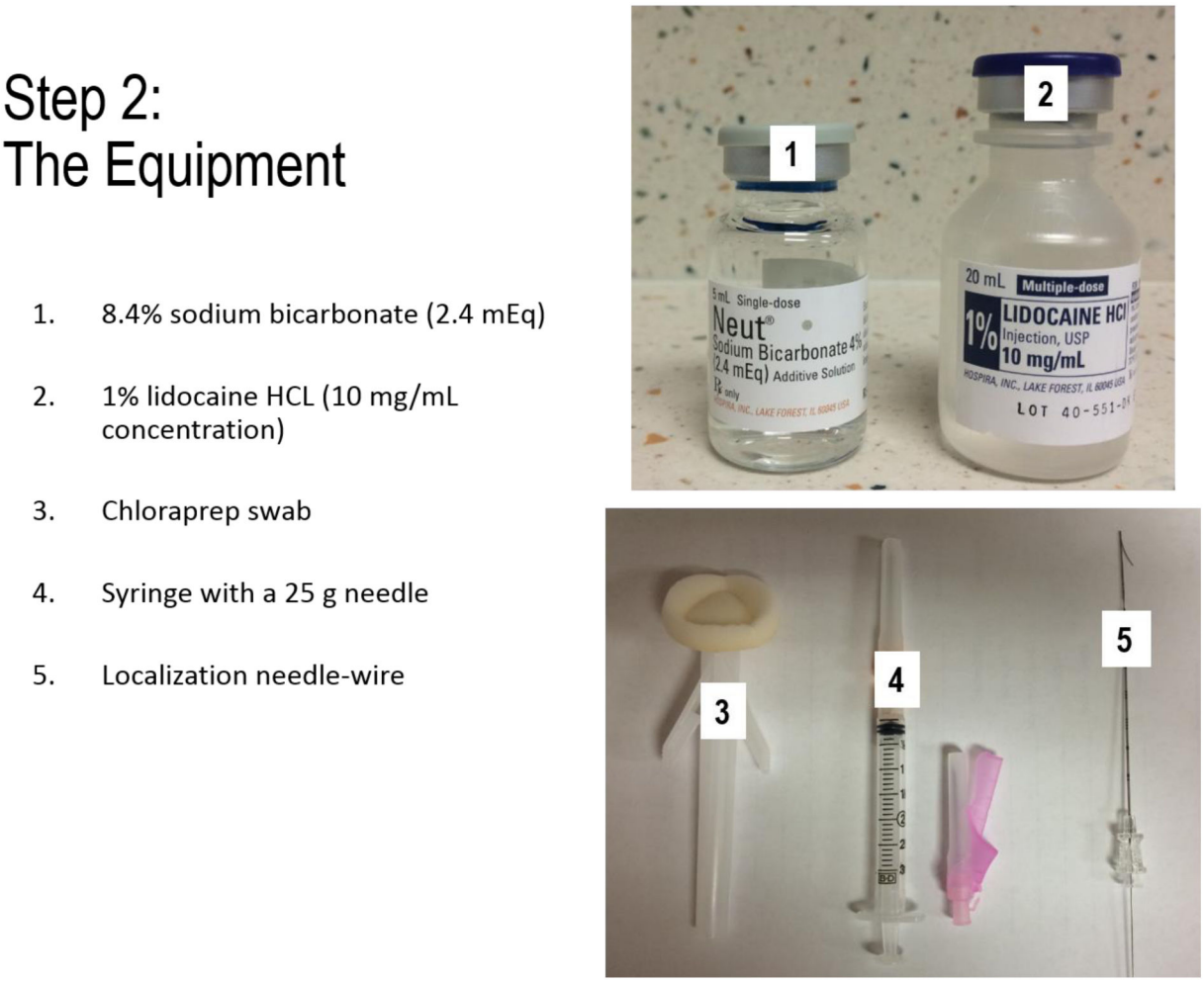


FIGURE 2A.
The most commonly used ancillary equipment for image-guided breast localizations.

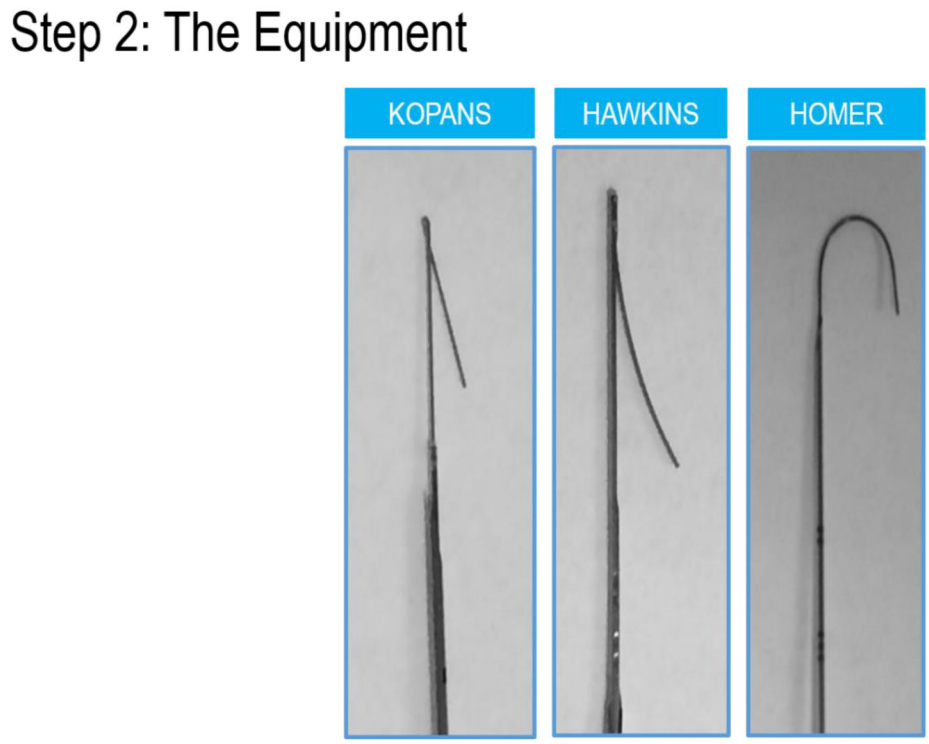


FIGURE 2B.
There are several options to consider when selecting a pre-loaded needle for wire localization, as depicted above.

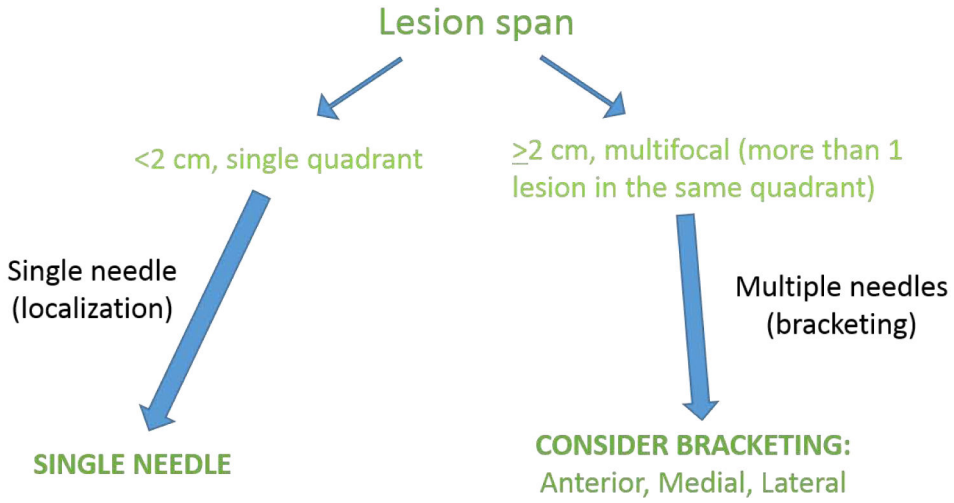


FIGURE 2C.

The number of needles required for successful wire localization depends on careful assessment of the size and the extent of the disease in the breast.

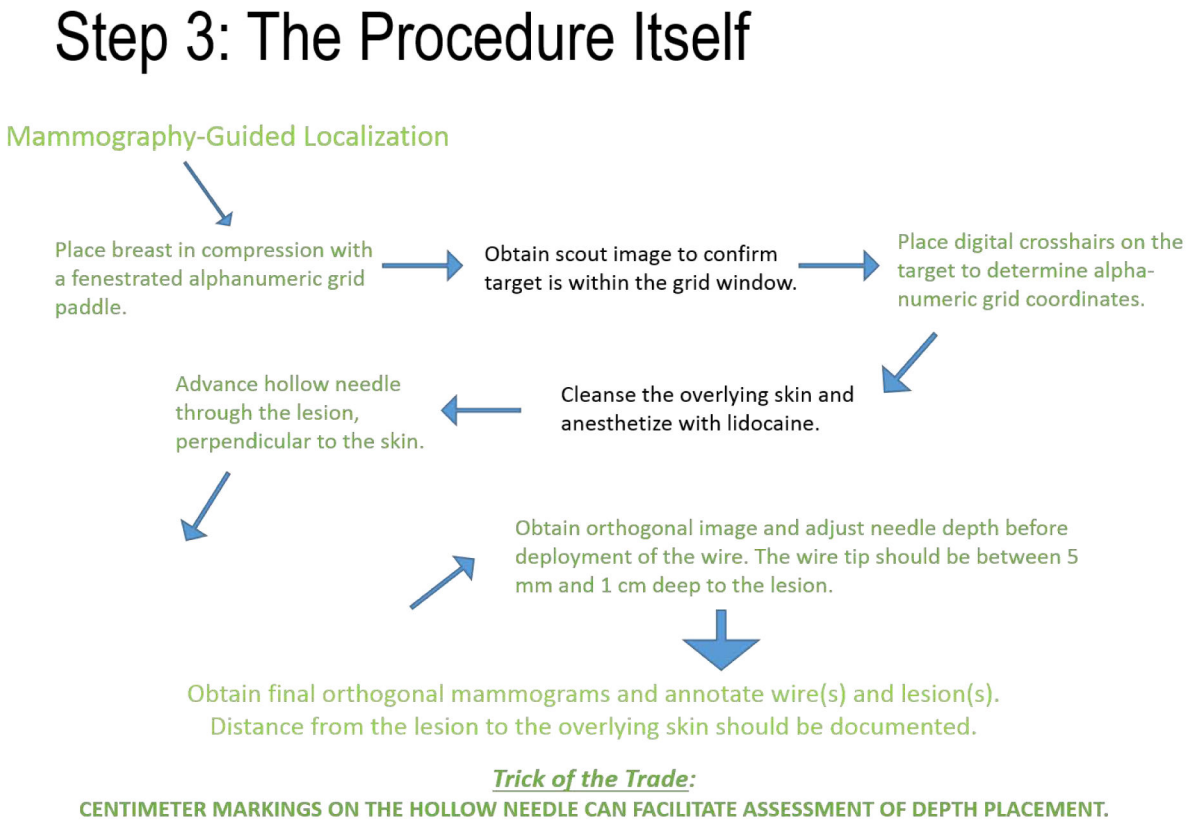


FIGURE 3A.
Procedural steps in mammography-guided wire localization.

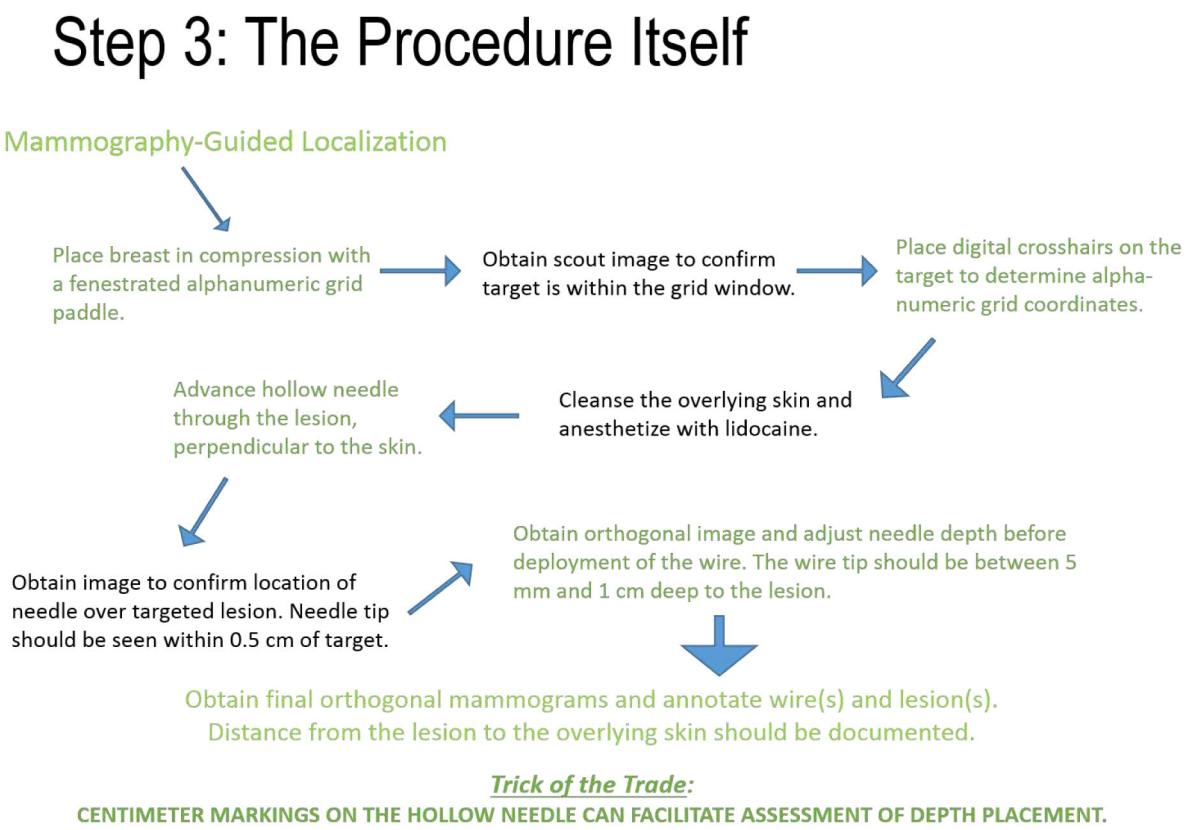
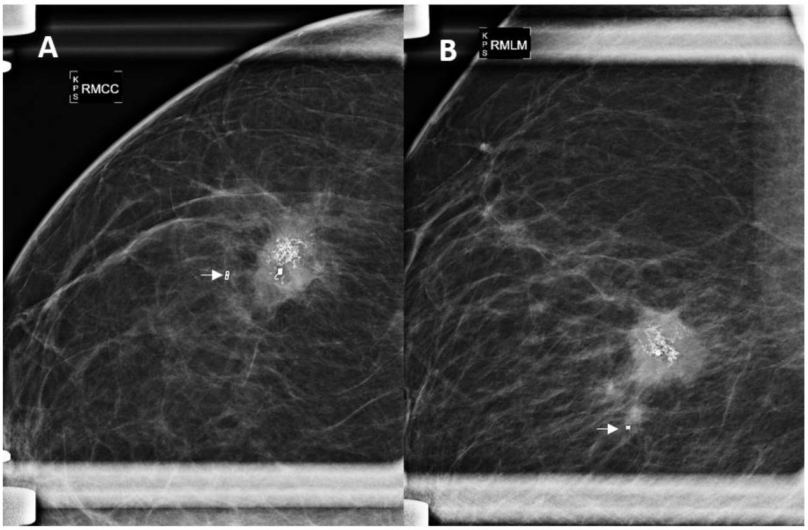


FIGURE 3B.
Procedural steps in mammography-guided wire localization.

Mammography-Guided Needle Localization: Mass and Calcifications

- 59-year-old female with a spiculated mass lesion and an associated marker clip. Ultrasound- guided biopsy revealed metaplastic carcinoma with associated DCIS.
- A, B - A second post biopsy clip is seen anterior and inferior to the index mass (arrow) and denotes site of MRI-biopsy proven DCIS. Total disease extent is estimated to be 3.5 cm.
- Approach: bracketing, lateral to medial
- Wires used: three 7 cm Hawkins needles



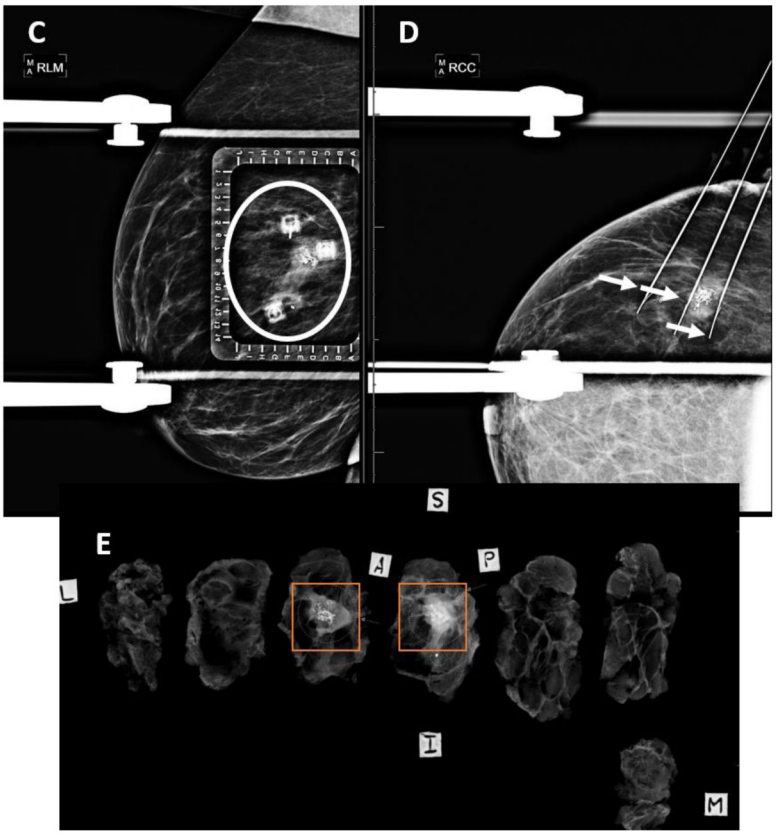
FIGURES 4A-B.
Step by step mammography-guided localization of a mass and calcifications.

Mammography-Guided Needle Localization: Mass and Calcifications

- C, D - Orthogonal mammographic views confirm successful localization of the lesion for excision. The three needles (circle) and deployed wires (arrows) are depicted.
- E - Specimen radiography confirms successful excision of the targeted lesion (boxes).

Teaching Points:

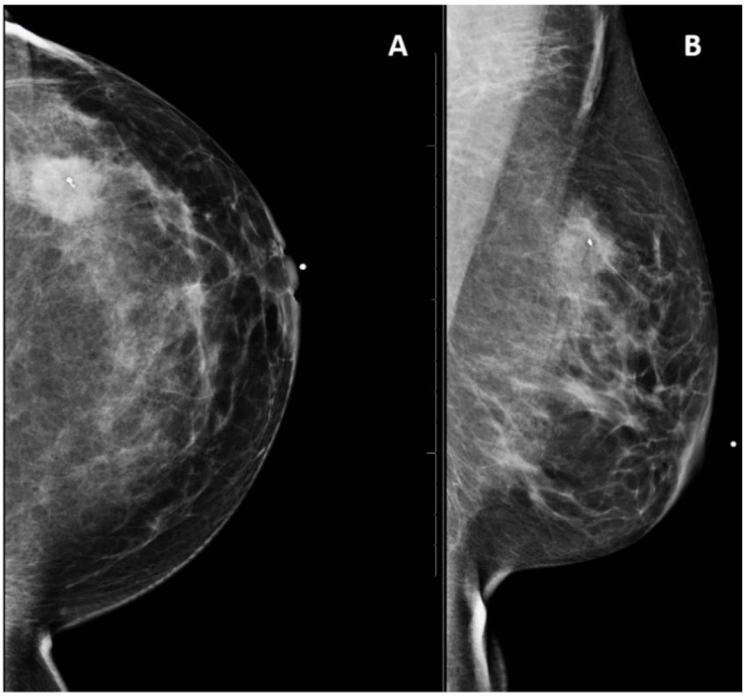
- Localization of lesions with associated calcifications needs to be performed under mammographic guidance.
- Lesions > 2 cm frequently require bracketing.
- Closest distance to targeted lesion should be selected for the approach.
- When placing multiple needles, approach localization systematically from posterior to anterior to avoid interference with previously placed needles.



FIGURES 4C-E.
Step by step mammography-guided localization of mass and calcifications.

Mammography - Guided Needle Localization: Complete Response to Neoadjuvant Chemotherapy

- A, B – 46-year-old female with an irregular spiculated mass and an associated marker clip in the upper outer left breast on craniocaudal (CC) (A) and mediolateral (MLO) (B) mammograms.
- C – Longitudinal ultrasound in the left breast at 2 o'clock shows an irregular hypoechoic mass. Ultrasound-guided biopsy revealed invasive ductal carcinoma.



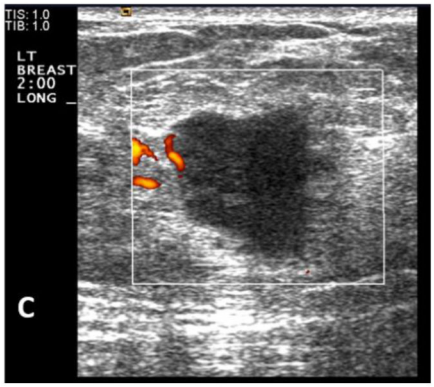


FIGURE 5A-C.
Mammography guided localization in a patient with complete response to neoadjuvant chemotherapy.

Mammography-Guided Needle Localization: Complete Pathologic Response to Neoadjuvant Chemotherapy

- Subsequent imaging following completion of neoadjuvant chemotherapy demonstrated absence of a discrete residual mass on both mammography and ultrasound.
- D, E, F - The footprint of disease is delineated by the post-biopsy clip, which is best seen on the mammograms.

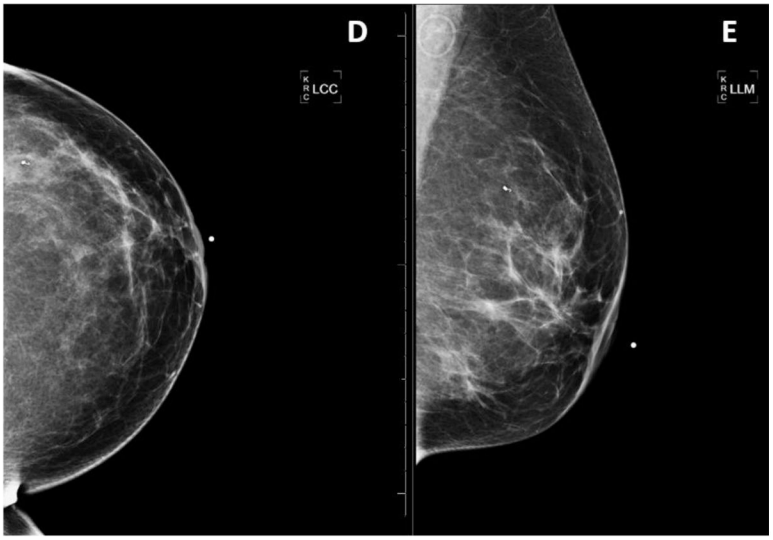


FIGURE 5D-F.
Mammography-guided localization in a patient with complete response to neoadjuvant chemotherapy.

Mammography-Guided Needle Localization
Complete Pathologic Response to Neoadjuvant Chemotherapy

- G,H - Orthogonal mammography views confirm successful localization of the post biopsy clip for excision.
- I- Specimen radiography confirms successful excision of the targeted clip (box).

Teaching Points:

- For patients undergoing neoadjuvant therapy, the footprint of residual disease must be localized.
- In patients with complete response to therapy, the clip marker must be localized.

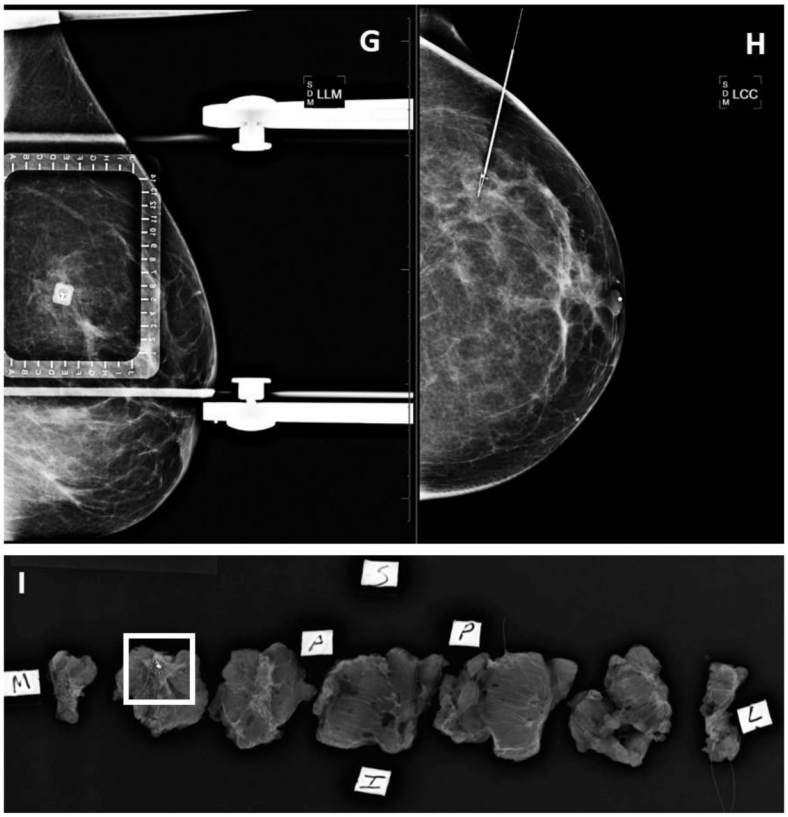


FIGURE 5G-I.
Mammography-guided localization in a patient with complete response to neoadjuvant chemotherapy.

Mammography-Guided Needle Localization: Post Biopsy Clip Migration

- A, B – 62-year-old female with a focal asymmetry and associated calcifications in the 12 o'clock region (arrow). Prior stereotactic biopsy of calcifications in this location revealed invasive ductal carcinoma and DCIS.
- The post biopsy clip (box) is 2 cm lateral and 4 cm inferior to the post biopsy cavity.

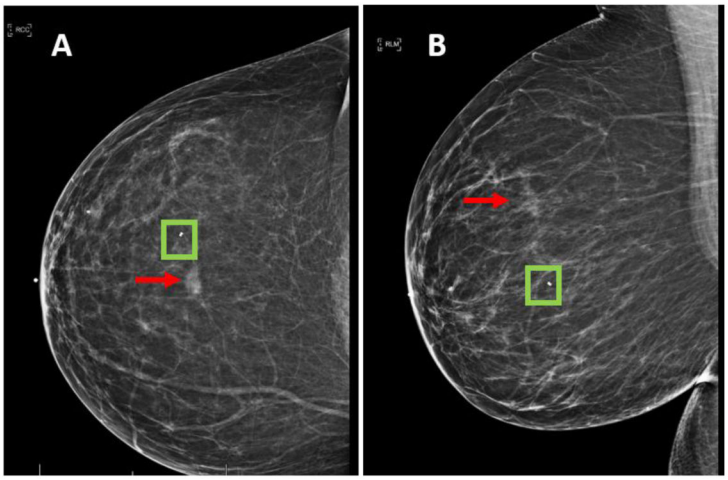


FIGURE 6A-B.
Mammography-Guided Needle Localization: Post Biopsy Clip Migration

Mammography-Guided Needle Localization and Post Biopsy Clip Migration

- C, D - Orthogonal mammographic views confirm successful localization of the residual calcifications and architectural distortion. Note that the migrated clip was not localized.
- E - Specimen radiography confirms successful excision of the targeted lesion (box).

Teaching Points:

- As a general rule, post-procedural mammograms should be obtained following any clip marker placement to document clip positioning relative to the targeted lesion.
- In patients with clip migration, the footprint of disease (not the clip) must be localized.
- Clip migration has the potential to occur most often following stereotactic and MRI guided biopsy as real time visualization of clip deployment is not possible with clip placement under stereotactic guidance.

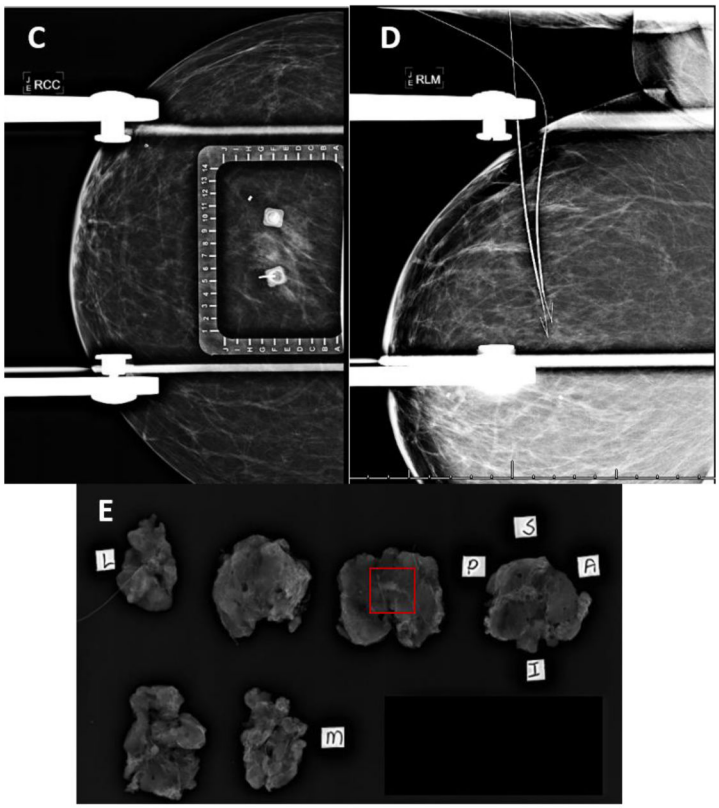


FIGURE 6C-E.
Mammography-Guided Needle Localization: Post Biopsy Clip Migration

Ultrasound-Guided Needle Localization: Single Mass on Ultrasound

- A, B – 51-year-old female with a lobular mass with an associated post biopsy clip in the upper outer left breast, as seen on the CC (A) and MLO (B) mammograms.
- C – Transverse ultrasound in the left breast at 2 o'clock shows an irregular hypoechoic mass. Ultrasound-guided biopsy revealed invasive ductal carcinoma.

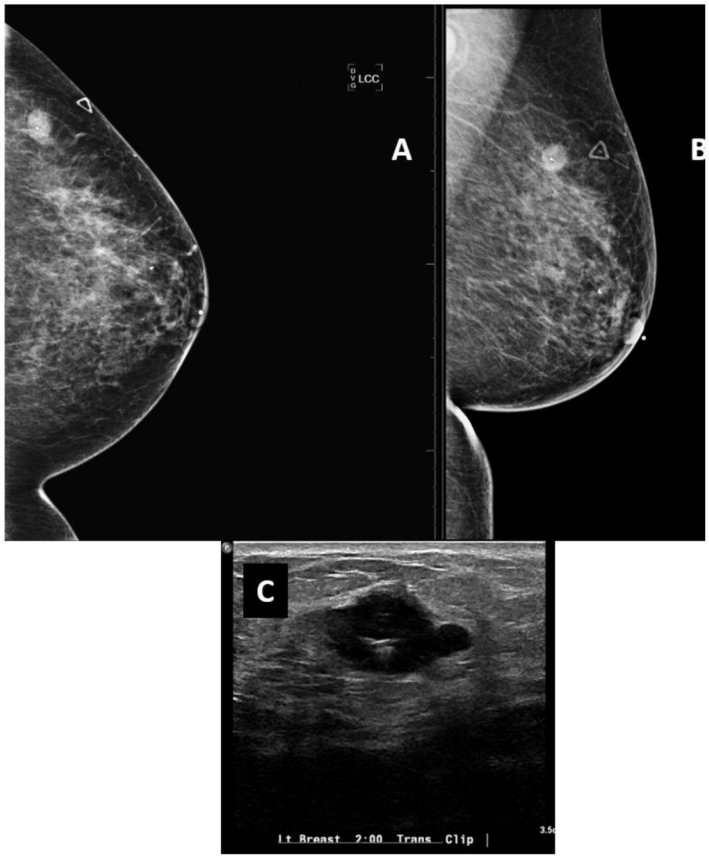


FIGURE 7A-C.
Ultrasound-Guided Needle Localization: Single Mass on Ultrasound

Ultrasound-Guided Needle Localization: Single Mass at Ultrasound

- Localization modality: Ultrasound
- Approach: lateral to medial
- Wire needle used: 5 cm Kopans

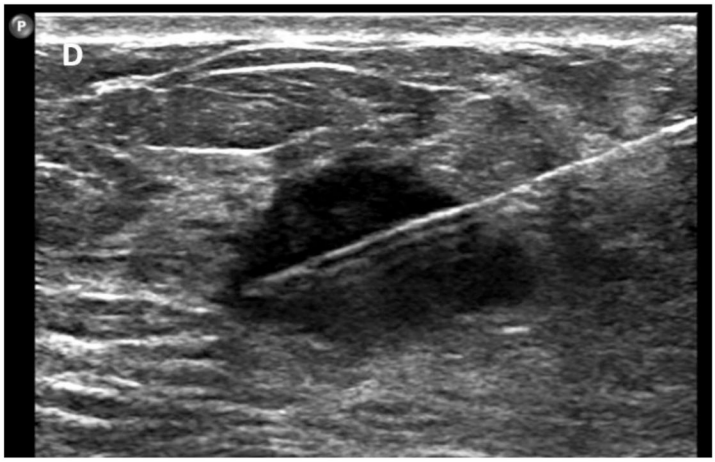


FIGURE 7D.
Ultrasound-Guided Needle Localization: Single Mass on Ultrasound

Ultrasound-Guided Needle Localization: Single Mass at Ultrasound

- E, F - Orthogonal mammographic views confirmed successful localization of the lesion prior to excision.
- G - Specimen radiography confirmed successful excision of the targeted lesion (boxes).

Teaching Points:

- Single non-calcified masses can be localized with ultrasound using a single wire.
- For lesions undergoing ultrasound-guided wire localization, intraoperative margin assessment with specimen radiography can assist the surgeon in obtaining more tissue if the initial margin appears close or positive.

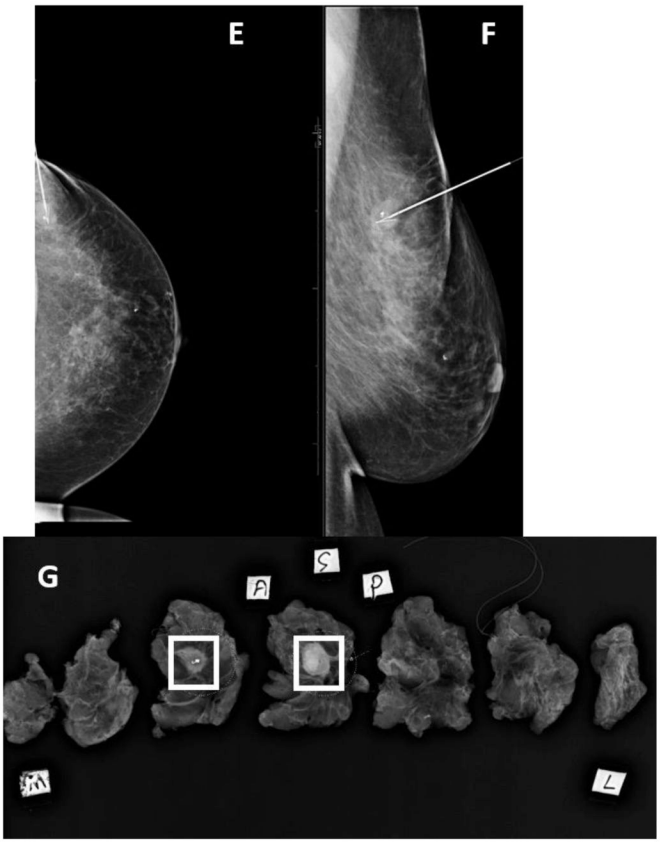


FIGURE 7E-G.
Ultrasound-Guided Needle Localization: Single Mass on Ultrasound

Ultrasound-Guided Needle Localization: Deployment of the Beaded Wire

- A – 44-year-old woman with an enlarging benign fibroepithelial right breast mass (box), presumed phyllodes tumor.
- B – Deployment of the hollow needle through the targeted lesion. Note that the needle tip is placed 1 cm past the lesion (arrow).

FIGURE 8A-B.
Ultrasound-Guided Needle Localization: Deployment of the Beaded Wire

Ultrasound-Guided Needle Localization: Deployment of the Beaded Wire

- C – Deployment of the wire through the hollow needle (arrow). The skin to wire distance should be documented and reported to the operating surgeon.
- D- CC mammographic view shows satisfactory positioning of the wire through the targeted lesion. Note the three beads along the distal wire, indicating the last three centimeters of the wire (arrowheads). The surgeon will begin excision, at the third or most proximal "bead" (green arrowhead). Therefore, the second bead (yellow arrowhead) should be at the middle of the specimen.

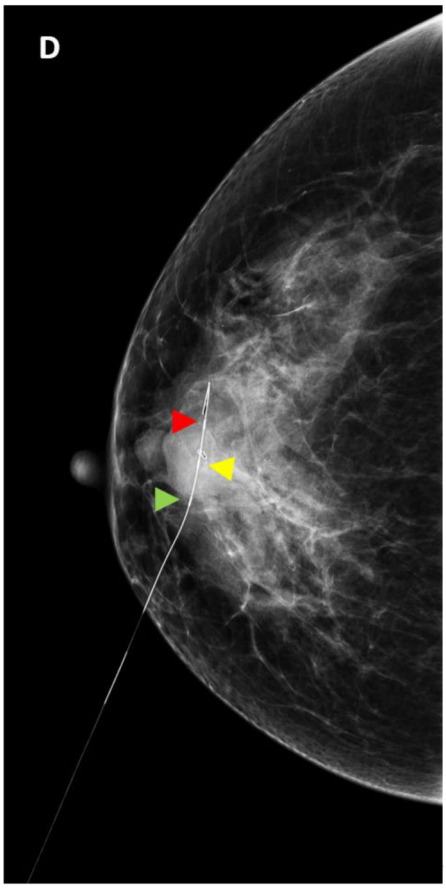


FIGURE 8C-D.
Ultrasound-Guided Needle Localization: Deployment of the Beaded Wire