

Rapid Implementation of Intraoperative Ultrasonography to Reduce Wire Localization in The Permanente Medical Group

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ABSTRACT

Context: Preoperative wire localization (WL), the most common localization technique for nonpalpable breast lesions, has drawbacks including scheduling constraints, cost, and patient discomfort.

Objective: To reduce WL use in our health care system, we investigated using hydrogel clips to facilitate intraoperative ultrasonography-guided lumpectomies.

Design: We retrospectively reviewed electronic medical records of patients with nonpalpable, ultrasound-visible breast lesions who underwent lumpectomy by 7 surgeons at 4 pilot sites in Kaiser Permanente Northern California between January 2015 and October 2015. Hydrogel clips, used for several years before the study period, were placed routinely during core-needle biopsy in all patients with nonpalpable, ultrasound-visible breast lesions.

Main Outcome Measures: Localization method, lesion size, margin positivity, and receipt of neoadjuvant therapy.

Results: One hundred forty-three patients underwent hydrogel clip placement and lumpectomy by pilot-site surgeons. Localization consisted of intraoperative ultrasonography alone, preoperative skin marking, or WL. Of the 143 patients, 71.3% did not need WL (60.8% ultrasonography alone and 10.5% skin marking). The non-WL and WL groups had similarly sized lesions, and the positive margin rate was 7.2% overall, with no significant difference between the non-WL and WL groups (5.9% vs 11.5%, $p = 0.33$). Of the 12 patients who underwent neoadjuvant chemotherapy, 8 (67%) did not require WL.

Conclusion: A multifacility protocol using intraoperative ultrasonography to visualize hydrogel clips was implemented, which decreased WL procedures and produced no significant difference in margin positivity between the WL and non-WL groups. This technique can be a cost-effective alternative to WL in patients who are candidates for hydrogel clip placement.

INTRODUCTION

The number of nonpalpable breast lesions detected on routine screening has increased with improving imaging technology, creating new challenges as surgeons must localize these lesions before removing them.¹ The most common localization technique is preoperative placement of a wire,² which has major drawbacks, including patient discomfort and delays to the operating room (OR) on the day of surgery.

Alternatives to wire localization (WL) include radioactive seed placement, placement of nonradioactive seeds, intraoperative ultrasonography, and intraoperative ultrasonography aided by an ultrasound-visible clip. Radioactive seeds have been used with excellent results.³⁻⁶ Unfortunately, the resources required to manage radioactive seeds can outweigh the benefits of the technique.

Furthermore, seed placement requires a second procedure before surgery.⁷ Several nonradioactive seed products have come onto the market, but data on these products are limited, the seeds can be very expensive, and they too require a second procedure for seed placement before surgery.⁸

Another approach is intraoperative ultrasonography.^{9,10} One advantage of this technique is that most hospital systems already have ultrasonography machines, which minimizes additional costs. The main downside is that intraoperative ultrasonography alone is very operator dependent, and this technique can be difficult to implement across large, diverse medical systems.

Several groups have described using hydrogel-based, ultrasound-visible clips (HydroMARK, Leica Biosystems, Cincinnati, OH) to facilitate intraoperative ultrasonography.¹¹⁻¹³ When the clip is placed during biopsy, it looks like a typical metal clip. Within a few days after deployment, the biodegradable hydrogel polymer that surrounds the clip absorbs fluid from adjacent tissue, creating a hypoechoic, ultrasound-visible “bubble.” Reexcision rates, specimen sizes, and complication rates are comparable between this technique and traditional WL.^{11,13} Furthermore, this technique does not require extra equipment other than the clip, and patients do not undergo procedures beyond the initial biopsy. Previous studies have described single-center and/or single-surgeon experiences.¹¹⁻¹³ We hypothesized that we could rapidly implement intraoperative ultrasonography aided by hydrogel clips across a large, diverse health care system to decrease WL use without sacrificing quality measures.

METHODS

As part of a performance improvement project to decrease WL, 4 Kaiser Permanente Northern California (KPNC) pilot sites used hydrogel clips in combination with intraoperative ultrasonography for patients undergoing lumpectomy. The breast imaging teams at each of these facilities had used hydrogel clips routinely for several years before initiation of this study to

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Table 1. Pilot-site surgeon volume, ultrasonography training, and prior experience

Facility in Northern California	Surgeon	No. of breast operations (2015)	Formal ultrasonography training (length of course)	Breast ultrasonography experience before January 2015
Fremont	1	186	Half-day workshop (4 h)	2 y
Fresno	2	86	Breast ultrasonography course (1 d)	2 y
	3	43	Head and neck ultrasonography course (1 d)	2 y
Oakland	4	185	Breast ultrasonography course (3 d)	3 y
	5	149	General ultrasonography course (1 d)	12 y
South San Francisco	6	88	Breast ultrasonography course (1 d)	14 y
	7	131	None	3 mo, with radiology backup

percutaneously mark all lesions undergoing biopsy using ultrasound guidance. Postbiopsy mammograms were performed after each biopsy to assess the accuracy of clip placement. Our study focused on nonpalpable, ultrasound-visible lesions identified during diagnostic workup of abnormalities identified on screening mammography. Patients with malignant, high-risk, or benign but discordant biopsy results were referred to the respective facility's Surgery Department, and pilot-site surgeons performed office-based ultrasonography during the initial office consultation to determine whether these patients were candidates for intraoperative ultrasonography. If the surgeon could visualize the clip and/or the mass easily with ultrasonography in the office, no additional localization procedures were performed before surgery. If the surgeon could not visualize the clip and/or mass well, preoperative skin marking (SM) or WL was requested. Localization procedures (SM or WL) were performed by breast imagers on the day of surgery, before patients went to the OR. In the OR, the surgeon performed a lumpectomy using intraoperative ultrasonography alone, intraoperative ultrasonography guided by SM, or WL with no intraoperative ultrasonography.

Breast imaging, biopsy, and pathology workflows at each facility followed standard KPNC protocols with comparable equipment at each site. Pilot-site surgeons had different breast surgery volumes and varying levels of experience with breast ultrasonography (Table 1), but all surgeons had access to ultrasonography machines in both the office and the OR.

We performed a retrospective review of the electronic medical records of all candidate patients from January 2015 to October 2015. Inclusion criteria were as follows: Nonpalpable, ultrasound-visible lesion; placement of a hydrogel clip during biopsy; and lumpectomy by 1 of the 7 pilot-site surgeons.

We examined localization type, lesion size, margin positivity, and whether patients received neoadjuvant chemotherapy. Comparisons were made between the group that required WL and the group that did not. Statistical analysis was performed using statistical software (Stata 13, StataCorp, College Station, TX). We used a Pearson χ^2 test for comparison of categorical variables and a *t*-test for continuous variables, with statistical significance defined as a *p* value less than 0.05.

This study was conceived and performed as a quality improvement project, and all activities in this study were carried out as part of routine clinical care. Thus, it was deemed by our institution not to require review by the institutional review board.

RESULTS

A total of 143 patients met inclusion criteria. All the patients were women, with ages ranging from 25 to 82 years. The distribution of lesion types is summarized in Table 2. Of the patients, 87 underwent only intraoperative ultrasonography and 15 had preoperative SM by the breast imaging team. In total, 71.3% (*n* = 102) of the patients avoided WL. Preoperative migration of the hydrogel clip, noted on postbiopsy mammogram, was seen in 3 cases (1.7%). Only 1 of these 3 patients required WL, because of the extent of clip migration and the surgeon's inability to visualize the lesion under ultrasound guidance.

The mean lesion size on imaging was 1.32 cm³ (range = 0–5.2 cm³). There was no statistically significant difference in lesion size between patients requiring WL and those patients whose lesions were localized with ultrasonography alone (Table 3). There also was no significant difference in mean tissue volume excised between the groups (Table 3). Most importantly, there was no significant difference in the rate of positive margins (Table 3).

Most of the pilot-site surgeons had experience with breast ultrasonography (Table 1). We did not track how many cases each surgeon performed before developing the confidence to use

Table 2. Lesion types

Diagnosis	Number of patients
Malignant	
Invasive ductal carcinoma (IDC)	87
Ductal carcinoma in situ	12
Invasive lobular carcinoma (ILC)	8
Mixed IDC and ILC	2
Other invasive subtypes	2
Total	111
High risk	
Atypical ductal hyperplasia	2
Lobular carcinoma in situ	2
Radial scar	1
Total	5
Other	
Benign papillary lesion	15
Fibroadenoma	6
Benign	5
Abscess	1
Total	27

intraoperative ultrasonography instead of WL. Notably, at our South San Francisco site, 1 of the 2 pilot-site surgeons began the study with minimal ultrasonography experience. During the course of 8 months, combining the data for both surgeons, we observed a steady decrease in the number and percentage of WL procedures, with no WL performed for ultrasound-visible lesions in the final 4 months and with a consistent case volume for each surgeon (Figure 1).

Twelve patients underwent neoadjuvant chemotherapy. The mean time from biopsy to surgery was 179.8 days. Only 4 patients (33%) required WL. Those who required WL had a longer interval before surgery (mean = 191 days) than those who did not require WL (mean = 174 days), although this difference was not significant ($p = 0.26$). One patient did not require WL despite clip placement 209 days before surgery.

DISCUSSION

This study is the first to examine the implementation of an intraoperative ultrasonography/hydrogel clip protocol for breast lumpectomies across a large, integrated health care system, in contrast to the single-surgeon and/or single-institution reports published in the literature.¹¹⁻¹³ Most surgeons in this study had some previous experience with ultrasonography, although the level of training ranged from no formal training to breast ultrasonography certification. For those with less experience, proficiency was achieved in a short time. The surgeon who had the least initial experience in breast ultrasonography was able to move completely away from WL for ultrasound-visible lesions within 5 months of starting the protocol. The combination of intraoperative ultrasonography and hydrogel clips reduced the need for WL in patients with ultrasound-visible, nonpalpable lesions, so that more than 70% of these patients did not need WL. We found no significant difference in lesion size, volume of tissue excised, or margin positivity between those patients who required WL and those who did not. The intraoperative ultrasonography/hydrogel clip technique also was effective in patients who required neoadjuvant therapy. Only 4 (33%) of these 12 patients required WL. This rate is consistent with the findings of other groups.^{11,13,14} Surprisingly, we found hydrogel clips to be visible on images for up to 209 days.

Interestingly, many of the pilot-site surgeons reported that the hydrogel clip served as a training tool, which helped increase their confidence with intraoperative ultrasonography in general. However, clip migration can be a concern. In our series, radiographic-evident preoperative clip migration was documented in only 3 instances (1.7%). One of the patients had substantial enough clip migration combined with poor ultrasonographic visualization of the index lesion to require a WL procedure. Klein et al¹² found

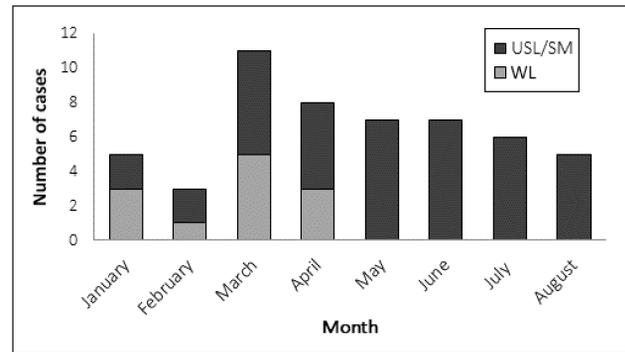


Figure 1. Localization of nonpalpable breast lesions by month at South San Francisco, CA, site.

USL/SM = ultrasonography alone/skin marking; WL = wire localization.

only 2 cases (6.4%) of true radiographic-proven clip migration, but they also found that extrusion of the biopsy marker intraoperatively during transection of the biopsy tract occurred up to 45.2% of the time. We did not review our clip extrusion rates. However, surgeons reported that although they could visualize the clip well by intraoperative ultrasonography and could remove the tumor successfully, sometimes they did not see the clip on the specimen mammogram. Presumably, this lack of visualization was caused by extrusion or accidental suction catheter removal of the clip. This suggests that another benefit of the technique is to eliminate the use of the hydrogel clip after an initial training period. Placing clips only in lesions that meet appropriate size and visibility criteria can increase the cost-effectiveness of the overall strategy.

The rapid learning curve and the decreasing dependence on the hydrogel clip are important considerations, especially because US surgeons have a wide spectrum of ultrasonography training and experience. Sclafani et al¹⁵ surveyed breast surgeons who completed fellowship training between 2005 and 2009. Even in this highly selected group of fellowship-trained breast surgeons, 31% of those who responded felt “poorly prepared,” 17% felt “moderately prepared,” and only 31% felt “well prepared” to use ultrasonography in practice. Extrapolating to the population of surgeons performing breast surgery in the US, most of whom are not fellowship trained,¹⁶ we can assume the level of comfort with ultrasonography is probably even more variable. We found that one of the strengths of the intraoperative ultrasonography/hydrogel clip technique is the ease and rapidity of adoption, independent of initial ultrasonography experience.

Our study has several limitations. First, the surgeons involved in the pilot study were volunteers interested in using cost-effective

Table 3. Wire localization versus ultrasonography localization alone

Variable	All patients	Wire localization	Ultrasonography alone	p value
Patients, No. (%)	143 (100)	41 (28.7)	102 (71.3)	
Mean lesion size, cm ³	1.2	1.1	1.3	0.24
Mean volume excised, cm ³	96.9	103.5	94.3	0.68
Positive margin rate for malignant diagnoses, %	7.2	11.5	5.9	0.33

alternatives to WL to decrease their WL rates. The general population of surgeons may not be as motivated to try intraoperative ultrasonography because this technique has a learning curve, requires practice, and necessitates coordination with a supportive Radiology Department. In a fee-for-service environment, breast imagers may not be as motivated to minimize WL use, as this could potentially compromise their revenue stream. In addition, we performed retrospective chart review rather than a randomized prospective study, which likely introduced selection bias. Tumors with better-circumscribed margins may have been more amenable to intraoperative ultrasonography, and these features could have contributed to the trends toward smaller lumpectomy volumes and lower rates of positive margins in the ultrasonography group. Notably, we did not attempt to correlate tumor type or other variables such as the depth and location of the tumor with positive margin rates or the need for WL, because the sample sizes were too small to make meaningful comparisons. Finally, ultrasonography is an operator-dependent modality, although the presence of an easily visualized hydrogel clip helps to mitigate the difficulty of identifying a breast lesion. Despite these limitations, the success of our pilot initiative as a proof of concept has led to an expansion of the project throughout KPNC. The next phase will include a formal training course for all breast surgeons in KPNC. We plan to track intraoperative ultrasonography use and outcomes both before and after training, and to develop a prospective database that will help us define variables that contribute to the success or failure of this technique.

CONCLUSION

We implemented an intraoperative ultrasonography/hydrogel clip alternative to WL for breast surgery in a large health care delivery system, with excellent outcomes. This required the coordination of surgeons and breast imagers across multiple facilities but was relatively easy to accomplish because of the strong integration of the KPNC health care system. Although we did not collect data on the patient day-of-surgery experience for our study, eliminating WL for many patients likely improved their surgical experience because WL can be a source of substantial distress and discomfort on the day of surgery.¹⁷

This technique is cost-effective. Our teams, using existing equipment, simplified OR scheduling, reduced ultrasound-guided WL procedures by more than 70%, and freed radiology resources for other breast imaging procedures. Collaboration with our breast imaging team was both feasible and beneficial in our integrated group practice, because time saved by not placing wires on the day of surgery allowed breast imagers to perform more screening and/or diagnostic breast examinations. With standard KPNC protocols, the elimination of 1 WL procedure frees resources to perform 4 screening mammograms, 2 breast ultrasonograms, and 1 screening mammogram, or 2 diagnostic workups. Our study demonstrates that intraoperative ultrasonography/hydrogel clip lumpectomy is a useful technique that surgeons across the nation can adopt easily. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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