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ORIGINAL ARTICLE – BREAST ONCOLOGY

A Prospective, Single Arm, Multi-site, Clinical Evaluation of a Nonradioactive Surgical Guidance Technology for the Location of Nonpalpable Breast Lesions during Excision

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ABSTRACT

Objectives. This study was a multicenter evaluation of the SAVI SCOUT® breast localization and surgical guidance system using micro-impulse radar technology for the removal of nonpalpable breast lesions. The study was designed to validate the results of a recent 50-patient pilot study in a larger multi-institution trial. The primary endpoints were the rates of successful reflector placement, localization, and removal.

Methods. This multicenter, prospective trial enrolled patients scheduled to have excisional biopsy or breast-conserving surgery of a nonpalpable breast lesion. From March to November 2015, 154 patients were consented and evaluated by 20 radiologists and 16 surgeons at 11 participating centers. Patients had SCOUT® reflectors placed up to 7 days before surgery, and placement was confirmed by mammography or ultrasonography. Implanted reflectors were detected by the SCOUT® handpiece and console. Presence of the reflector in the excised surgical specimen was confirmed radiographically, and specimens were sent for routine pathology.

Results. SCOUT® reflectors were successfully placed in 153 of 154 patients. In one case, the reflector was placed at a distance from the target that required a wire to be placed. All 154 lesions and reflectors were successfully removed during surgery. For 101 patients with a preoperative diagnosis of cancer, 86 (85.1 %) had clear margins, and 17 (16.8 %) patients required margin reexcision.

Conclusions. SCOUT® provides a reliable and effective alternative method for the localization and surgical excision of nonpalpable breast lesions using no wires or radioactive materials, with excellent patient, radiologist, and surgeon acceptance.

Multiple technologies have been used to guide the surgical excision of nonpalpable breast lesions. Wire localization (WL) is routine and represents the standard to which other methods are compared.[1] The presence of a localization wire constrains the path of the surgical approach and carries risks of dislodgement, migration, and/or transection, which may result in a loss of localization.[1–3] The need to have wire placement and localization on the same day causes scheduling challenges for the radiology and surgical departments. Patient satisfaction also may be negatively impacted by long wait times between the wire

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placement and surgery, discomfort from the protruding wire and an increased risk of vasovagal syncope associated with presurgical fasting.[1–3]

Localization using radioactive seeds instead of wires obviates these constraints. Studies have found that radioactive seed localization (RSL) is safe, reliable, and offers easier removal of the target lesion, lower margin positivity, fewer re-excisions, better patient care coordination, and increased patient satisfaction.[3–6] In particular, radioactive seeds can be placed in the breast days before surgery. Even with implantation times from one to several weeks in advance of surgery, no clinically significant migration of radioactive seeds was observed in a prospective study.[7] RSL also allows more efficient scheduling of radiology and surgery procedures by allowing them to be decoupled. One study found that after RSL was instituted, there was a 34 % increase in utilization of scheduled biopsy slots, a 50 % savings in time spent scheduling, and a 4.1-day average decrease in biopsy wait time.[8] Time between mammogram and biopsy is increasingly important as this is a tracked metric in the National Quality Measures for Breast Centers initiative.[9] However, an important disadvantage of radioactive seeds is the additional safety procedures required for handling radioactive materials, including licensing, staff training, tracking, record-keeping, and other regulatory hurdles.[3,10,11]

Another alternative to WL is localization by intraoperative ultrasound (IOUS). Meta-analyses suggest that IOUS yields lower rates of positive margins and optimal excision volume compared with WL.[12,13] Chart review of hundreds of consecutive patients who underwent partial mastectomy by a single physician showed that use of hydrogel markers at the time of diagnostic biopsy correlated with markedly less frequent use of WL and no significant difference in specimen volume or rate of reexcision compared with standard markers.[10] Similar rates of reexcision were found in a retrospective review that compared ultrasound and WL.[14]

This study examines SAVI SCOUT® (Cianna Medical, Inc.), a nonradioactive breast localization and surgical guidance technology. This study expands on the experience from a 50-patient pilot study to assess the performance of SCOUT® across multiple institutions and physicians.[15]

METHODS

SCOUT® utilizes nonradioactive micro-impulse radar (MIR) technology to provide real-time surgical guidance. MIR uses emitted and reflected radar pulses to locate objects. The SCOUT® system consists of an implantable reflector, a handpiece, and a console (Fig. 1).

FIG. 1 SAVI SCOUT® system components

A 16-gauge delivery needle is used to insert the 1.2-cm reflector into the target tissue under image guidance. The handpiece emits pulses of infrared light and radar into the breast tissue and receives a radar signal back from the implanted reflector to provide direction and proximity to the reflector and target lesion in real-time. The pulsing infrared light modulates the reflector so that it returns a unique radar signal to the handpiece. The console processes the returned radar signal to provide audible and visual feedback, which increases in cadence and numerical readout with increasing proximity of the handpiece to the reflector, thus guiding surgical removal of the lesion. The system received FDA 510(k) clearance in August 2014.

Eleven sites (Table 1) in seven states received approval from an appropriate local or national institutional review board for a common protocol that met the guidelines of the responsible governmental agencies. Patients who were scheduled for breast-conserving surgery or excisional biopsy of a nonpalpable breast lesion were enrolled in this prospective study from March through November 2015. Consented patients who met the eligibility criteria (Table 2) had a SCOUT® reflector placed, targeting either the lesion or an existing biopsy marker. Techniques similar to those used for placement of localization wires were used for placement of the reflector. The reflector was supplied preloaded in a needle for positioning and deployment. After deployment, the signal from the reflector was detected by the SCOUT handpiece and console, and placement of the reflector was confirmed by ultrasound or mammogram. The planned surgical excision took place up to 7 days after placement of the reflector with intraoperative localization of the reflector guiding the excision. The handpiece and console also were used to determine that the reflector was in the excised tissue. Removal of the reflector was verified by specimen radiograph and specimens were sent for routine pathology. Patient experience surveys were completed after the reflector placement and before surgery.

The primary endpoints of the study were the rates of successful reflector placement, localization, and retrieval. The secondary endpoints included percent of cases with

TABLE 1 Patient enrollment

Institution	Radiologists	Surgeons	Patients enrolled	Patient age (years)	
				Average	Range
USF Breast Health Program	3	1	15	59.5	41–77
Morton Plant-Mease Hospital	4	2	22	62.8	38–83
Nashville Breast Center	1	1	23	66.1	42–89
Pink Lotus Breast Center	0	1	13	54.2	36–75
Cancer Centers of Colorado	1	2	16	56.9	42–75
UC Irvine Health	1	2	14	50.6	35–64
NYU Langone Medical Center	5	3	18	52.6	29–73
Medical Center of Plano	1	1	19	58.6	39–75
Baylor Regional Medical Center at Plano	2	1	4	63.0	53–69
Texas Breast Specialists	0	1	4	53.8	46–61
Hackensack University Medical Center	2	1	6	62.9	49–80
All cases	20	16	154	58.8	29–89

TABLE 2 Patient eligibility criteria

Inclusion criteria	Exclusion criteria
Patient has a nonpalpable breast lesion that requires excision	Patient had a previous ipsilateral breast cancer
Patient is scheduled for excision or BCT at a participating institution	Patient has multicentric breast cancer
	Patient has Stage IV breast cancer
Patient is between the ages of 18 and 90 years	Patient has been treated with neoadjuvant chemotherapy
Patient is female	Patient is pregnant or lactating
Patient is willing and able to comply with study procedures and be available to follow-up for the duration of the study	Patient has an implanted pacemaker or defibrillator
	Patient has known or suspected allergic reactions to materials similar to the components of the SAVI SCOUT reflector (nickel)
	Patient has any condition that would place the individual at increased risk or preclude the individual's full compliance with or completion of the study

clear margins, percent of cases requiring reexcision, physician experience compared with WL, patient comfort, and overall experience. Upon conclusion of the trial, physician experience surveys were completed by all participating radiologists and surgeons.

RESULTS

Of 167 patients who were evaluated for study participation, seven patients elected to have another type of surgery, four patients had scheduling problems, one patient was possibly allergic to nickel, and one patient was ineligible because she had a pacemaker. Thus, 154 patients were consented and treated per the study protocol (Table 1).

Reflectors were successfully placed in or near the breast lesions of 153 (99.4 %) of the 154 participating patients, including 65 under radiographic guidance (2D or 3D mammography, or stereotactic) and 89 under ultrasound guidance (Table 3). In one stereotactic-guided placement, post-placement images showed the reflector was 2.5 cm from the biopsy marker, resulting in conversion to wire placement as per the study protocol. Overall, reflectors were placed at a mean depth of 2.6 (range 0.2–8.0) cm from the skin and at a mean distance of 2.8 mm from the target (range 0–25 mm). Reflectors remained implanted for up to 7 days before excision.

Following placement, reflectors were detected from the skin in 147 of 153 patients who had reflectors successfully placed. In six cases, the reflector was not detected from the skin surface post-placement. In four of these cases, wires were placed as a backup in case the reflector could not be detected in surgery, as per study protocol. In two other cases, wires were placed because the target biopsy marker was not visible on ultrasound and three additional patients had wires placed as a backup while the surgeons gained experience with their initial cases. In all of these cases except one, the reflector was detected from the skin preincision in surgery and SCOUT® was used as the primary localization technique. In the remaining case, the excision was guided primarily by the wire (Table 4).

TABLE 3 Reflector placements and localizations

	All cases
Reflector placements	154
Mammography guidance	65
Ultrasound guidance	89
Reflector distance from skin (cm)	
Average	2.6
Range	0.2–8.0
Reflector distance from target (mm)	
Average	2.8
Range	0–25
Success of reflector placement	153/154
Reflector localizations	153
Excisional biopsies	40
Lumpectomies	113
Days reflector placed before excision	
Average	1.8
Range	0–7
Reflector excision	
Reflector detected before incision	150/153
Reflector localized after incision	151/153
Reflector successfully removed	153/153
Reflector detected in specimen radiograph	149/153
Reflector Intact	153/153
Surgeon evaluation	
Ease of localization[a]	4.4
Ease of removal[a]	4.3

[a] Compared with WL, scale of 1–5 where 3 = same as WL, <3 is worse than WL, >3 is better than WL

Surgical localization occurred for 153 patients with 52 and 101 undergoing excisional biopsy and lumpectomy, respectively. Reflectors were detected preincision at the time of surgery in 150 of 153 patients. The reflectors were successfully removed in all cases during surgery. For 101 cases in which there was a preoperative diagnosis of cancer and excision with clear margins was the surgical intent, pathology showed that two cases were benign, 36 had in situ carcinoma only, and 63 had invasive cancer with or without in situ disease. The average tumor size was 1.7 (range 0.1–13.2) cm. Eighty-six (85.1 %) patients had clear margins, but 15 (14.9 %) of these had a close margin to within 1 mm. An additional 15 (14.9 %) patients had positive margins. Seventeen patients (16.8 %) underwent a second operation for reexcision, including 13 patients with positive margins and 3 patients with close margins.

Of 52 SCOUT®-guided excisional biopsies, pathology revealed 42 patients with benign lesions and ten patients with invasive and/or in situ carcinoma. Of the ten malignancies, seven had close (<1 mm) or positive margins, five of which required additional surgery.

Following each case, surgeons compared their SCOUT experience with their previous WL experience. On a Likert scale of 1–5, where 1 was "worse than WL," 3 was "equivalent to WL," and 5 was "better than WL," the average rating for SCOUT was 4.4 for ease of localization and 4.3 for ease of removal.

Surveys of patients' experiences with SCOUT were completed by 110 of 113 study patients who had the reflector placed before surgery. Of the 105 patients who answered the question about satisfaction with SCOUT®, 75 (71 %) were very satisfied, 14 (13 %) were somewhat satisfied, 13 (12 %) were neutral, and 3 (3 %) were somewhat dissatisfied. Ninety-seven percent would recommend SCOUT® to other patients. Of the 59 patients who worked outside the home, 18 worked on the day of placement and 23 worked after placement of the reflector, while the reflector was in place.

Reflector placement surveys were completed at the conclusion of the trial by 18 participating physicians, including 14 radiologists and 4 surgeons. Based on a Likert scale of 1–5 (see above), implanting physicians rated SCOUT® 3.7 for patient comfort, 3.8 for patient anxiety, and 4.1 for overall patient experience. Of the 13 physicians who answered the query about workflow, 11 (85 %) reported a workflow improvement with SCOUT® relative to WL.

Reflector localization surveys were completed by 14 participating surgeons following completion of the study. On average, surgeons rated SCOUT better than WL for incision site planning, tissue localization, confidence in removing the correct target, and ease of specimen removal with Likert scores of 4.3, 3.9, 4.0, and 3.9, respectively. Surgeons also rated SCOUT® as 4.9 for the ability to start cases earlier, 4.4 for patient wait times, and 4.4 for a reduction in OR schedule delays.

DISCUSSION

The findings of this multicenter, prospective trial of SCOUT® demonstrate that SCOUT® can be safely and reliably used in clinical settings where breast surgery is routinely performed. This study validates findings from a 50-patient pilot study of SCOUT®, which found that the technique resulted in a high rate of surgical success and a low rate of margin reexcision. In that study, the technology was found to be highly intuitive, reliable, and easy to implement and was strongly favored by surgeons compared with WL.[15]

Radiologists in this study reported a better patient experience with SCOUT relative to WL, which aligns with the RSL experience compared with WL.[6] Because the reflector can be placed several days before surgery,

TABLE 4 Surgical pathology

	Excisional biopsies[a]	Lumpectomies[a]	All cases
Number of cases			
USF Breast Health	5	10	15
Morton Plant-Mease Hospital	8	14	22
Nashville Breast Center	0	23	23
Pink Lotus Breast Center	4	9	13
Cancer Centers of Colorado	4	11	15
UC Irvine Health	7	7	14
NYU Langone Medical Center	11	7	18
Medical Center of Plano	7	12	19
Baylor Regional Medical Center at Plano	3	1	4
Texas Breast Specialists	0	4	4
Hackensack University Medical Center	3	3	6
All	52	101	153
Final diagnosis			
Benign	42/52	2/101	44/153
DCIS only	6/52	36/101	42/153
Invasive cancer only	3/52	23/101	26/153
DCIS + invasive cancer	1/52	40/101	41/153
Tumor size (cm)			
Average	1.1	1.7	1.6
Range	0.1–2.4	0.1–13.2	0.1–13.2
Amount of tissue excised (cm^3)			
Average	41.2	135.1	101.5
Range	2.7–283.3	6.0–651.8	2.7–651.8
Margin status			
All margins clear	50/52	86/101	136/153
Positive margin	2/52	15/101	17/153
Close margin (1 mm)	5/52	15/101	20/153
Required re-excision	5/52	17/101	22/153
Surgeon evaluation			
Ease of localization[b]	4.5	4.4	4.4
Ease of removal[b]	4.2	4.4	4.3

[a] Cases with a preoperative diagnosis of cancer were classified as a lumpectomy; otherwise, were they classified as an excisional biopsy

[b] Compared with WL, scale of 1–5 where 3 = same as WL, <3 is worse than WL, >3 is better than WL

SCOUT® uncouples the localization schedule from the surgery schedule, thus allowing placement of the reflector at the convenience of the patient and radiology department. SCOUT® also allows the flexibility to place the reflector from any direction without impacting the surgical approach. These advantages are similar to those noted in a recent study following implementation of a RSL program: improved efficiencies in scheduling, ability to remove blocks on the schedule previously held for same-day wire placements, utilization of unused WL slots for biopsy thereby decreasing biopsy wait times, and the elimination of operating room delays caused by delays in radiology.[8]

Surgeons rated their SCOUT® experience as better than their previous WL experience for ease of localization and removal of lesions. Although this multicenter study did not provide a direct comparison, the reexcision rate observed was comparable to those reported in multicenter RSL and IOUS studies and was significantly better than WL with rates reported as high as 60 %.[5]

A key technique identified during the pilot study was the need to move the handpiece slowly and deliberately on the skin surface to allow the system time to detect the reflector. The system is more directional than ultrasound or gamma probe used for RSL or sentinel lymph node identification and provides optimal detection when the handpiece is pointed towards the reflector. Based on these differences, we recommend training on the handpiece technique before first cases.

Based on clinical experience, a maximum depth of 4–5 cm is recommended for initial cases while gaining experience with the technology. The pilot study used a 3-cm depth limitation, but this exclusion was removed in this study per investigator input with detections occurring up to 8.0-cm deep. The suggested detection technique includes placing the patient in the supine position and, for deeper lesions, using compression with the handpiece. The average skin-to-chest wall distance in the ultrasound-guided cases ($n = 89$) was 3.5 cm, with 83.1 % ($n = 74$) less than 5 cm in depth. For the ultrasound cases with tissue depths less than 5 cm, the reflector was placed at a mean depth of 1.4 cm, and for cases with tissue depths greater than 5 cm, the reflector was placed at mean depth of 3.7 cm.

As previously mentioned, three reflectors were not detected preincision at the time of surgery. In one case, detection before incision was not attempted due to the surgeon knowing the location of the reflector based upon ultrasound imaging. In two cases, nondetection was likely associated with halogen operating room lights. Halogen lamps emit infrared radiation and some older model OR lights can pass through enough infrared light onto the surgical field to affect detection of the reflector. One surgeon noted that simply shielding, dimming, or redirecting the halogen lights slightly away from the breast while using the handpiece enabled full detection of the reflector. As such, halogen lights do not preclude the use of SCOUT®. LED lamps, which are becoming more prevalent in operating rooms and do not emit infrared radiation, were not found to interfere with SCOUT® localization.

In three cases, electrocautery disabled the reflector upon specimen excision with no negative impact on the surgical dissection. As a result, the manufacturer incorporated an additional component into the reflector to maximize detectability should it come into contact with a cautery device. Cautery can be used routinely with SCOUT®. It is recommended that the handpiece be used multiple times during dissection and removal to ensure the location of the reflector is known.

SCOUT® allows for scheduling flexibility for patients, physicians, and institutions. Reflectors were placed during both morning and afternoon procedures. Some patients worked the day of reflector placement and on days between placement and excision. Patients generally reported low anxiety and small discomfort with the reflector placement, and almost all patients would recommend SCOUT® to other patients. No adverse events occurred, and no migration of the reflectors was observed. Future areas of study include placement of multiple reflectors for bracketing and placement for lymph node localization.

Based on these findings, SCOUT® is a safe and effective method for breast localization and surgical guidance using no wires or radioactive materials. Surgeons found SCOUT to be more precise than WL with the ability to start cases earlier with fewer OR delays. Radiologists reported a better patient experience and improved workflow with SCOUT compared with WL. Thus, SCOUT should contribute to more efficient use of radiology and surgery schedules and staff time in centers that perform breast localization procedures.

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