

ENHANCED SENTINEL LYMPHOSCINTIGRAPHIC MAPPING IN BREAST TUMOR USING THE GRADED SHIELD TECHNIQUE

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The graded shield technique was developed to increase the sentinel node detection rate by improving lymphoscintigraphic image contrast. In a 6-month period, 50 women with clinical suspicion of early stage breast cancer (T1 and T2 tumors) were enrolled in this study. The patients had a mean age of 47.2 ± 10.3 years. A composite graded shield was constructed using three concentric layers of leaded plastic measuring 3 cm, 5 cm, and 7 cm each in diameter. The graded shield was designed with a movable Velcro backing for accurate positioning over the injection site. Images were acquired with a vertical angle dual-head gamma camera using an established injection procedure developed at our institution. The rate of detection of sentinel lymph nodes using lymphoscintigraphic mapping improved from 74% (37/50 patients) to 96% (48/50) using the graded shield ($p < 0.05$). In addition to the increased detection rate, our technique also increased the number of nodes detected and improved visualization of the adjacent lymphatic basin. By enhancing nodal contrast, we have demonstrated that the graded shield technique is an effective method for improving the rate of sentinel node detection.

Key Words: sentinel lymph node, breast cancer, graded shield
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Sentinel lymph node (SLN) biopsy was developed to assess the axillary nodal status of patients with early stage breast cancer; in current practice, axillary lymph node dissection can be avoided in patients with negative SLNs [1–3]. Lymphoscintigraphic mapping is an essential part of radio-guided SLN biopsy and could be used in preoperative localization of SLNs

within the entire lymphatic drainage basin. However, high quantities of radioactivity at the primary injection site create “shine through”, which hinders SLN detection in lymphoscintigraphy [4]. In order to decrease this interference, our approach was to incorporate a graded shield to mask the activity at the injected area and to enhance imaging of SLN drainage. In our series of 50 patients, this technique improved the rate of detection of SLNs.

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MATERIALS AND METHODS

Patients

In a 6-month period from November 2001 to April 2002, 50 women with clinical suspicion of early stage

breast cancer (T1 and T2 tumors) were enrolled in this prospective study. Patients had a mean age of 47.2 ± 10.3 years (range, 31–83 years) at the time of these diagnostic investigations. The most common location of the lump was in the outer upper quadrant of the breast.

Graded shield design

We designed a composite graded shield composed of three concentric layers of leaded plastic pads. These pads, with diameters of 3 cm, 5 cm, and 7 cm, were affixed to one another with rubber cement (Figure 1). Each layer was 0.25 cm thick with a measured attenuation factor of three for 140 keV gamma photons. The graded shield was also designed with a movable Velcro backing for easy positioning at the injection site during imaging.

Lymphoscintigraphic protocol

Patients underwent lymphoscintigraphy between 16 and 18 hours prior to surgery. Patients were positioned supine with arms raised. A dose of 11.1–22.2 MBq (0.3–0.6 mCi) of ^{99m}Tc sulfur colloid was injected without filtration (100–1,000 nm), in 0.4 mL to 1.0 mL of saline, subdermally and peritumorally at the palpable tumor or biopsy site. Using the graded shield, 30 10-second frames of dynamic scintigraphic images were acquired immediately. Static scintigraphic images (anterior and lateral views of 500 k counts) with and without graded shields were obtained using a vertical angle, dual-head gamma camera (Siemens E.CAM, Siemens Medical Systems Inc., Hoffman Estates, IL, USA). The distance between the gamma detectors and the patient was about 15 cm to 20 cm. Focal accumulations of nodal radioactivity in the axillary

basin distinct from the injection area were considered to be SLNs.

Enhancement of SLN scintigraphic mapping

For independent evaluation of the outcomes, two sets of static images with and without graded shields were presented to two nuclear medicine specialists for interpretation. The lymphoscintigraphy findings were then tallied in one of three categories as “easy”, “equivocal”, or “poor” identification. A note was made of any additional SLNs detected and SLNs whose identification was facilitated by the use of graded shields. The exact location of SLNs was confirmed by intraoperative gamma probe detection (neo2000[®], Neoprobe Corp., Dublin, OH, USA). The *t* test was used for statistical analysis.

RESULTS

We confirmed that all SLNs identified on preoperative lymphoscintigraphy were consistent with intraoperative gamma probe findings. Diagnostic results based on the 50 patients are summarized in Figures 2 and 3. Figure 2 shows a 24% improvement in the easily identified group using the graded shields. However, even with the graded shields, two patients had nodal activity poorly identified by preoperative lymphoscintigraphy. Also, one case that was initially categorized as easily identified became equivocally identified when graded shields were applied. These exceptional cases will be discussed in detail. By

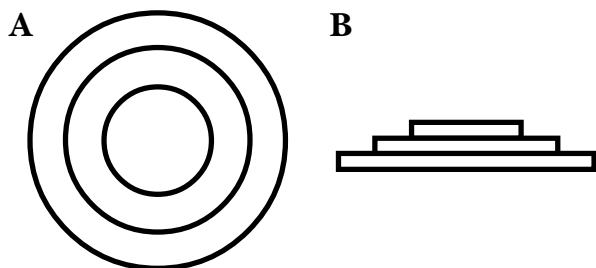


Figure 1. The composite graded shield. (A) Three concentric, leaded plastic pads, with diameters of 3 cm, 5 cm and 7 cm, form the graded shield. (B) From the lateral view, each pad has equal thickness with one-third-attenuation effect.

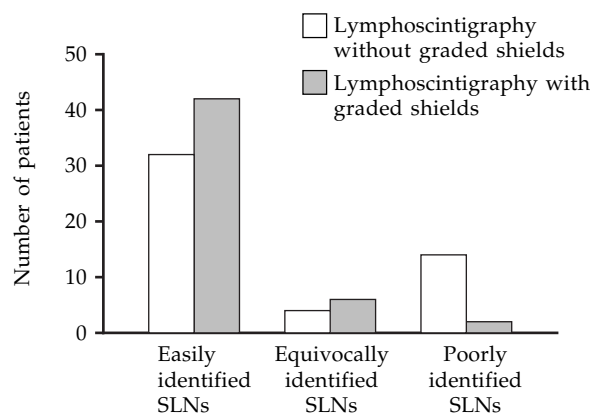


Figure 2. Comparison of sentinel lymph node (SLN) detection rates in lymphoscintigraphic mapping with and without graded shields.

combining the easily and equivocally identified groups, the total SLN detection rate increased from 74% (36/50 patients) to 96% (48/50 patients) with graded shields ($p < 0.05$). The improvement in nodal detection with graded shields is shown in Figures 4 and 5.

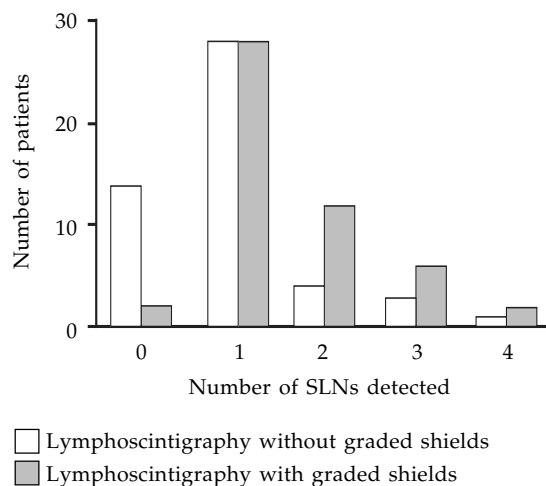


Figure 3. Comparison of the number of axillary sentinel lymph nodes (SLNs) detected in lymphoscintigraphic mapping with or without graded shields among the easily identified and equivocally identified nodal groups.

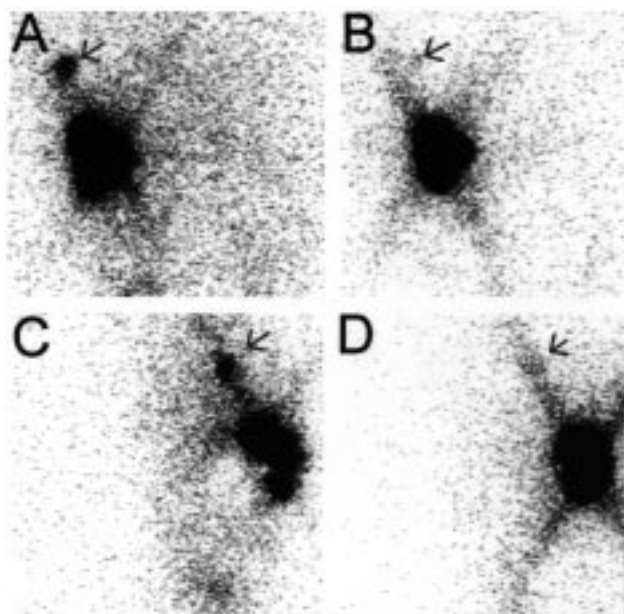


Figure 4. Right breast tumor in a 56-year-old female. The sentinel lymph nodes (SLNs; arrows) are more easily identified with than without graded shields on lymphoscintigraphic mapping. (A) Anterior view with a graded shield. (B) Anterior view without shielding. (C) Right lateral view with a graded shield. (D) Right lateral view without shielding.

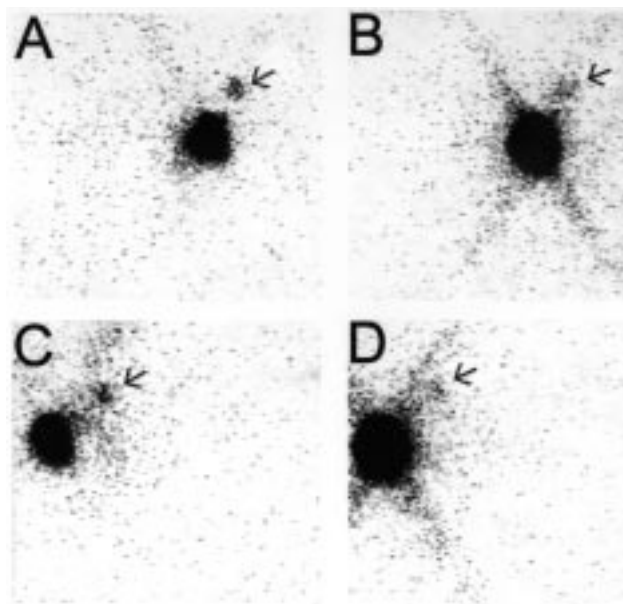


Figure 5. Left breast tumor in a 52-year-old female. The equivocally identified sentinel lymph nodes (SLNs; arrows) are easily identified when graded shields are used. (A) Anterior view with a graded shield. (B) Anterior view without shielding. (C) Left lateral view with a graded shield. (D) Left lateral view without shielding.

The shielding technique increased the total number of SLNs detected in the “easy” and “equivocal” groups. Although most of these patients had only one detected node, additional nodal activities were identified in 12 patients when graded shields were used, as shown in Figure 3. A typical clinical case for additional nodal detection is presented in Figure 6. Graded shielding improved not only detection of the total number of SLNs, but also the delineation of adjacent lymphatic tracts.

DISCUSSION

Most investigators agree that preoperative lymphoscintigraphic mapping can provide surgeons with valuable information about the orientation of the major lymphatic drainage basin from the tumor site and the location of SLNs [5,6]. In certain cases, primary lymphatic drainage is also found to internal mammary nodes and other locations outside the axilla that can only be identified by preoperative lymphoscintigraphy [7]. Therefore, lymphoscintigraphy allows the surgeon to plan the incision before use of an intraoperative gamma probe [6]. The incision can be made based on

knowledge of the location and number of SLNs or secondary nodes.

In published literature, investigators have visualized SLNs with lymphoscintigraphy in 75% to 98% of patients [5]. Many technical factors, such as particle size, dose and volume of radiopharmaceuticals, injection site, and imaging parameters, can result in different outcomes in identifying SLNs [4,6,8]. Optimizing the image acquisition time, shielding the injection site from scattering, and acquiring at least two imaging projections are necessary to ensure SLN detection. Previous studies suggest that injection of a combination of smaller radioisotope dose (0.1–0.3 mCi) and volume (0.1–0.3 mL) may diminish the effect of injection site scattering [9]. Low injection dose and/or volume may be suitable for a single subdermal or periareolar injection, but visualization of internal mammary SLNs is improved with abundant injected dose volume. Therefore, a modified combination of peritumoral and subdermal injections is considered optimal for lymphatic mapping [1,10]. A dose of 0.4 mCi to 1.0 mCi in a volume of saline is widely accepted [11,12]. Using the shielding technique and an adequate injection dose/volume improves imaging of the lymphatic drainage basin and identification of SLNs

in breast cancer.

The ability to detect a focus of increased activity in the presence of background activity is dependent on many factors. These include the overall spatial resolution of the imaging system, the amount of scattered radiation in the image data, and the contrast between the lesion and background activity [13]. The attenuation effect of graded shields reduces the scattered background radioactivity. Therefore, image contrast is enhanced and detection of SLN activity and delineation of the adjacent lymphatic drainage are both improved. By visual comparison, using graded shields increased the contrast between SLNs and background radioactivity in 47 of our series of 50 patients.

Previously, we employed a square leaded rubber pad of uniform thickness, but discovered that it attenuated nearby SLNs as well as the injection activity, resulting in false-negative results. In this series, the most common location for the breast tumor was the outer upper quadrant, and the axillary SLNs were typically seen in the low axilla, as in a previous study [12]. A shorter distance between the breast tumor and axillary SLNs results in significant scattering from injection activity. As an alternative, we designed a graded shield to vary the attenuating factors around the injected site and potential nearby SLNs. Thus, we can avoid inappropriate shielding and optimize the identification of SLNs, thereby improving the rate of SLN detection.

As previous studies report, certain individuals demonstrate variations in breast lymphatic drainage secondary to age, previous operative scar, or tumor location, which can result in difficulty in SLN identification [3,6,12]. We encountered three exceptional cases in our study. In two of these cases, the SLNs remained in the “poor” identification category even when the graded shield was used. One of these patients was a young female with previous scarring. The second was an older woman, and age may have resulted in reduced local lymphatic function of the breast. We consider these individual lymphatic variations to be a challenge to SLN detection on lymphoscintigraphy even with our graded shield technique. Oddly, the third case had an SLN in the “easy” identification category without shielding, but which became “equivocal” with the graded shield. In this rare case, the reverse of the desired effect may have occurred because the SLN was located near the

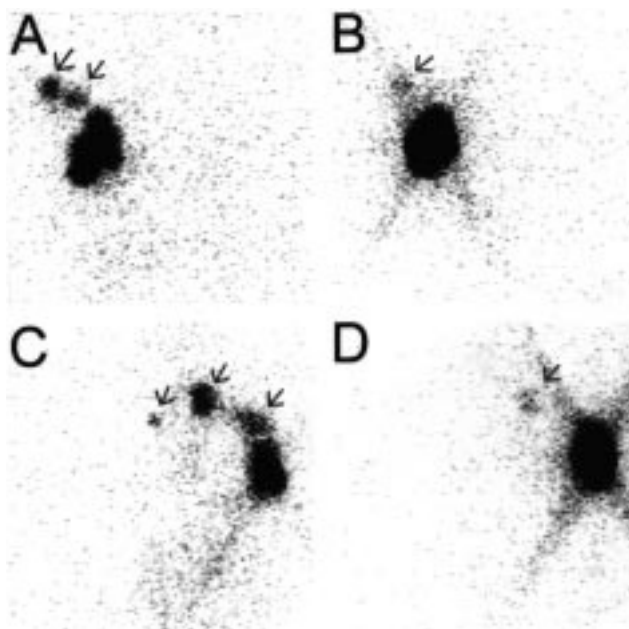


Figure 6. Right breast tumor in a 31-year-old female. Additional sentinel lymph nodes (SLNs; arrows) are visualized on lymphoscintigraphic mapping with graded shields. (A) Anterior view with a graded shield. (B) Anterior view without shielding. (C) Right lateral view with a graded shield. (D) Right lateral view without shielding.

injection site and covered by the graded shield. To address this potential pitfall, we intend to develop a graded shield with a smaller diameter.

Preoperative lymphoscintigraphic mapping is valuable in providing details of the lymphatic drainage basin and location of SLNs for preoperative surgical planning. Many technical factors contribute to the different reported SLN detection rates. A graded shield at the palpable tumor or biopsy site improves SLN contrast in lymphoscintigraphy and is an effective method to improve the accuracy of SLN detection.

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