Dual Modality Surgical Guidance for Non-palpable Breast Lesions

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Abstract. Currently, the majority of lumpectomy and excisional biopsy procedures are performed using the wire localization (WL) technique; however, this technique suffers from several drawbacks including inaccuracy in placement of the wire, possible displacement of the wire prior to surgery, and ambiguity of the lesion's location along the wire. We propose dual modality surgical guidance (DMSG) as a means to overcome many of the problems associated with WL. The approach uses a dual modality (digital mammography and breast scintigraphy) breast imaging system developed in our lab to place a small radioactive marker (a radiomarker), directly into the lesion. Here we present the results of measurements of the localization and injection accuracy of our system. The localization accuracy, evaluated by determining the difference between the known and measured inter-well separations, were within 0.76 mm (standard deviation of 0.46 mm) of the true distances for x-ray imaging and within 0.66 mm (standard deviation of 0.43) for gamma imaging. Our maximum error in injection accuracy in any of the three Cartesian coordinates was 1.8 mm. On average, the errors were 0.6, 0.4, and 0.9 mm for x, y, and z respectively. The results of these phantom tests provide encouragement that our upright digital mammography unit can accurately a) locate a lesion in three dimensions, b) inject a radiomarker into the lesion, and c) assess the offset between the lesion and radiomarker centers.

1 Introduction

Major clinical trials have shown that for patients with Stage II breast cancer, the survival rate of women receiving breast conservation therapy (lumpectomy/ radiation) is similar to that of women undergoing mastectomy [1]. Furthermore, no increased risk of second malignancies has been demonstrated in patients who select breast conservation therapy as opposed to mastectomy [2]. Thus, there has been a shift away from mastectomy and towards breast conserving procedures. Concurrently, recent advances in mammography have significantly improved the detection of early stage breast cancers, presenting surgeons with the increasingly difficult tasks of lesion localization and complete lesion excision.

Currently, the majority of lumpectomy and excisional biopsy procedures are performed using the wire localization (WL) technique. In WL, a guide wire is placed through the lesion on the day of surgery. Along with the mammographic images, the

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surgeon uses the wire, which extends through the skin, to locate the tissue to be excised. Although this is the current standard of practice, the WL technique suffers from several drawbacks including, 1) ambiguity in the location of the lesion along the wire, 2) the possibility that the wire can get displaced prior to surgery, and 3) the fact that the entry point of the wire and its orientation within the breast cannot be relied upon as an optimum entry point and path for incision and dissection. One consequence of uncertain intraoperative lesion localization is the increased likelihood of positive margins, potentially necessitating a second surgery. Efforts to avoid this can result in the removal of needlessly large masses of breast tissue to reduce the risk of residual malignancy. Also, since WL must be performed on the day of surgery due to risk of displacement of the protruding wire, surgical procedures requiring it cannot be scheduled early in the surgical schedule. These consequences result in increased cost, morbidity and trauma for the patient, and increased logistical problems for the surgeons and radiologists involved, and have motivated the search for alternative, more accurate methods for intraoperative localization of nonpalpable breast lesions.

One possible solution to the problems associated with WL is to provide the surgeon with intraoperative guidance by means of a small radioactive marker, placed directly into the lesion. During surgery a hand-held gamma probe is used by the surgeon to locate and excise the marked lesion. Such an approach has been tested by researchers at the H. Lee Moffit Cancer Center at the University of South Florida (using implanted radiotherapy (^{125}I) seeds as radiomarkers) and investigators at the European Institute of Technology in Italy (using ^{99m}Tc-labeled macroaggregated albumin), and has shown promising results [3-6](De Cicco et al., 2002; Gennari et al., 2000; Gray et al., 2001). Our approach, known as dual modality surgical guidance (DMSG), uses an upright dual modality (digital mammography and breast scintigraphy) breast imaging system developed in our lab. A photo of the system is shown in figure 1. In this approach, the x-ray component of the dual modality breast scanner is used to identify the 3-dimensional location of the lesion within the breast. A 3-axis translation system, mounted on the mammography unit, is then used to accurately inject a small amount of a radiolabeled substrate (radiomarker) into the center of the lesion. The gamma imaging component is then used to verify the position of the radiomarker relative to the lesion as seen on the x-ray images.

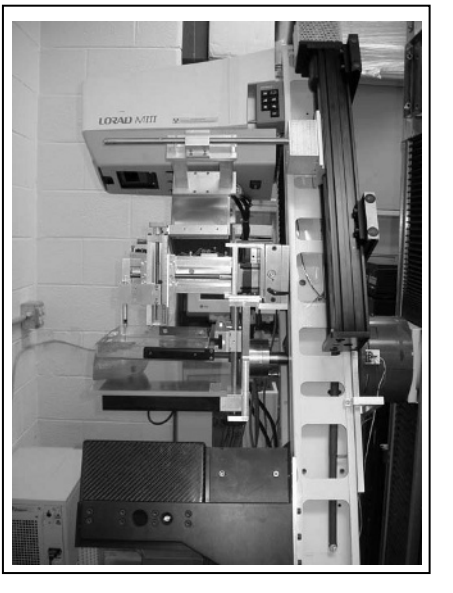

Fig. 1. Photo of the dual modality scanner modified to perform radiomarking

Here we present the results of measurements of the localization and injection accuracy of our system.