TACTILE IMAGING: A METHOD FOR DOCUMENTING BREAST LUMPS

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Abstract: We present a new method of imaging the breast and other soft tissues that promises to improve the documentation of size of breast lumps. This system makes a series of distributed pressure measurements and averages them into a composite tactile map of the palpable structure. We estimated lump size from tactile maps made in a limited clinical trial. The system proved to be nearly three times as accurate as ultrasound and manual estimates of lump size.
Keywords: Breast imaging, tactile sensing, pressure maps.

Introduction: The majority of referrals to a breast specialist are due to a palpable breast lump [1]. In many cases clinical breast examination (CBE) using palpation is the best way of examining these lumps. Because it is difficult to verbalize and record tactile sensations there is a need to improve clinical breast examination documentation to provide a repeatable, stable examination.

There have been a number of new methods of improving breast examination proposed which rely on the palpable elastic stiffness contrast between tumors and normal tissue [2,3]. These techniques are typically intended for screening and diagnosis. We propose a new type of medical imaging that relies on distributed pressure measurements made of the breast. We hypothesize that it will provide more accurate and repeatable documentation of the size of breast lumps than mammography, ultrasound and CBE.

Methods: The tactile imaging system is inexpensive, quick and easy to use. It is based on a hand held scan head (Figure 1a) that the physician strokes over the breast. It has a 416 element piezo-resistive distributed pressure sensor mounted on the head and a magnetic position tracker in the handle. A computer digitizes the tactile pressure images and locations while the physician strokes it over the breast. A tactile map, (Figure 1b), which is the spatial average of all of the pressures onto a best-fit plane, is created in real time [4].

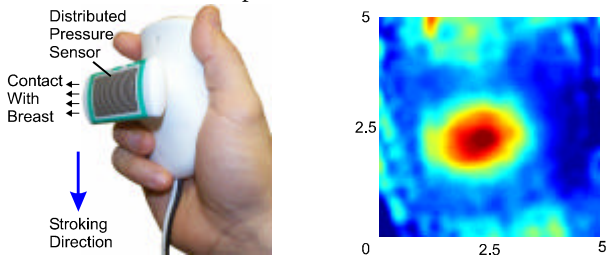

Figure 1- (a) The tactile imaging scan head. (b) A tactile image of an infiltrating ductal carcinoma, red is the highest pressure, and is the center of the lump.

To determine the repeatability and accuracy a limited clinical trial of 25 breast cancer surgical patients was conducted. Each patient received 3 to 5 tactile maps just prior to surgery and lump size was estimated from these maps using a thresholding algorithm [5]. After excision the palpable size of the lumps was measured with calipers and compared to the size estimates from tactile imaging, CBE and ultrasound images (Figure 2).

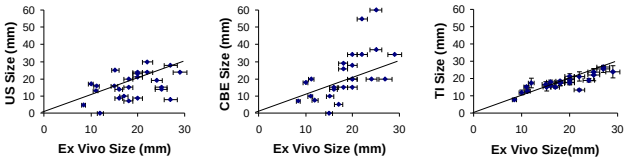

Figure 2 – (a) Ultrasound (US), (b) CBE and (c) Tactile Imaging (TI) maximum size estimates compared to ex vivo maximum size. Abscissa error bars are +/- 5% ex vivo size estimate variation, while those on the ordinate are the standard deviation of the three to five tactile maps. None are shown for the other modes because only one examination was performed. Both US, and CBE show one lump at zero diameter; these lumps were not visible or not palpable.

Discussion: Tactile imaging shows mean absolute error (MAE) of 12%, while ultrasound shows 34% and CBE shows 47%. This result demonstrates that tactile imaging is nearly three times as accurate as the other commonly available breast examination techniques. In addition, it is potentially more sensitive because it imaged one lump was not palpable, and one was not visible in the ultrasound images.

Across multiple maps made of the same lump using different examination techniques, size estimate repeatability was found to be 7.5% (one standard deviation). A just noticeable difference between two examinations is 15% (95% confidence) which compares favorably with the 40% change for CBE [6]. This demonstrates that tactile imaging is more repeatable than these other measurement techniques.

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