Infrared Physics and Technology 91 (2018) 214–219

Contents lists available at ScienceDirect

Infrared Physics & Technology

journal homepage: www.elsevier.com/locate/infrared

Regular article

Role of digital infrared thermal imaging in the diagnosis of breast mass: A pilot study
Diagnosis of breast mass by thermography

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ARTICLE INFO

Keywords:
Thermography
Breast cancer
Fibroadenoma
Temperature
Granulomatous mastitis
Ductal carcinoma

ABSTRACT

Background: This paper summarizes the role of Digital Infrared Thermal Imaging (DITI) in the diagnosis of breast mass.

Methods: Of total, 54 patients with palpable breast mass were enrolled in the study. Using DITI, minimum, average and maximum temperature values of each lesion site and its counterpart were measured, differences were used as a measure of symmetry. 0.5 °C was selected as a reference cut-off. Subsequent to thermal imaging, all patients underwent US examination. Mammographic examination was performed upon clinician request. All lesions were core-biopsied. Results of thermal imaging according to the above-mentioned criteria was compared with histopathological results.

Results: Pathological evaluation revealed 21 invasive ductal carcinoma, 18 fibroadenoma, 9 cyst and 6 granulomatous mastitis. When mean temperature values were evaluated, fibroadenomas differed from malignant lesions significantly, whereas there was not statistically significant difference between granulomatous mastitis and invasive ductal carcinoma. Cysts were significantly different from malignant lesions only in terms of maximum temperature. It was shown that DITI can differentiate benign lesions from malignant with sensitivity up to 95.24% and specificity up to 72.73%.

Conclusion(s): This pilot study has shown that DITI can play a role in differentiating fibroadenoma and cyst from invasive ductal carcinoma in patients with palpable breast-mass. Since fibroadenomas are mostly seen in younger women, emergence of thermal symmetry analysis as an adjunct method in symptomatic patients with dense breasts seems most promising and important.

1. Introduction

Breast-mass complaints were the most common cause of referral (89.91%) for breast cancer patients to surgery clinics in Turkey [1]. Opportunistic screening made only 4% of referrals in these patients. These results can be attributed to low breast health awareness, difficulty accessing to screening services and socio-cultural factors. This situation might be improved with a screening tool reaching communities rather than waiting for symptoms to get screened.

Today, mammographic screening is still the only option for early breast cancer detection [2]. Breast ultrasound (US) is used mostly as an adjunct method in case of focal abnormality on a previous mammogram [3]. But, those methods have limitations. For instance, radiation exposure, reduced sensitivity in dense breasts and low specificity yielding too many biopsies are disadvantages of mammography (MMG) [4,5]. Breast ultrasound is operator dependent and magnetic resonance imaging (MRI) -which is recommended for specific group of patients- costs too much. Also, they require technical expertise and manpower. Furthermore, access to breast cancer screening is limited in many suburban and rural areas of Turkey due to lack of units [6].

Initial examples of medical thermal imaging had been introduced in the middle of last century but due to lack of technical capability and analysis tools, it was abandoned [7]. Primary origin point for thermal imaging is that human body is homoeothermic and body temperature changes are useful indicator of health status [8]. With the development of better sensors and analysis tools, thermography resurges in medical

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https://doi.org/10.1016/j.infrared.2018.04.019
Received 8 April 2018; Received in revised form 30 April 2018; Accepted 30 April 2018
Available online 02 May 2018
1350-4495/

imaging. It adds critical information to the best possible evaluation of breast. It confers advantages over conventional techniques for being portable, non-invasive, easily conducted, repeatable, and inexpensive. Moreover, contrast agent isn't required.

Considering advantages of DITI and socio-economic status of the Turkish population, infrared thermography can be a useful investigation where the clinical diagnosis is in doubt and the conventional methods are far from reach. In this regard, this pilot study was conducted to determine potential of DITI as an adjunct tool in diagnosis of breast masses in Turkish scenario.

2. Patients and methods

2.1. Study design and ethical aspects

This prospective, single-center, double-blinded diagnostic accuracy study was performed between May and September 2016 at Kayseri Training and Research Hospital with Erciyes University School of Medicine Research Ethics Committee approval under protocol number 2016/111. For this purpose, thermographic and radiological examiners were blinded to clinical breast exam and to each other.

2.2. Eligibility criteria

A total of 160 patients with breast complaints were referred to Kayseri Training and Research Hospital Department of General Surgery during 5 months period. The inclusion criteria for the participants were as follows: female patients aged between 18 and 70 years old and diagnosed with single breast lump on clinical examination. The exclusion criteria were as follows: patients with history of previous breast surgery or treatment, family history of breast cancer, presence of acute infection or chronic systemic diseases such as diabetes or vascular diseases, having bra cup size bigger than DD, obese patients (Body Mass Index > 30), use of non-steroid anti-inflammatory/steroid drugs or any other medication concurrently that could systemically or locally affect skin temperature (Fig. 1).

2.3. Thermal imaging procedure

Subsequent to clinical breast exam, the clinicians marked the lesion of concern and filled a thermography request sheet containing location of each lesion for reference of both the interpreting surgeon and radiologists. All patients were told to refrain from exercise, smoking and alcohol at least a day before the imaging procedure. Thermal images were taken at the time of admission for post-menopausal patients. For pre-menopausal patients, 5th to 12th days or 21th day of menstrual cycle was preferred for least engorgement [9]. Exclusion criteria was determined according to the review by Cuevas and colleagues about factors influencing the use of thermography [10].

For digital infrared thermal imaging procedure, FLIR ThermaCam E45 (FLIR Systems Inc., Wilsonville, Oregon, USA) was used. This infrared camera detects signals over the spectral range of 7.5–13 μm and have an image resolution of 320 × 240 pixels. Its operating temperature range is from −20 °C to +250 °C with temperature resolution 0.1 °C at 25 °C.

Thermal images were taken in a room which was kept at constant 22–25 °C with humidity 50% ± 15%. The room and the patients weren't exposed to direct sunlight or air-flow. In order to avoid bias, the surgeon who took and interpreted thermal images was unaware of the patients' complaints, examination findings and imaging results such as detailed ultrasonography and mammography.

The operation and the device to be used were told to the patients and after taking patient consent, they were asked to remove their clothes and raise their hands above the head. After 15 min of rest to let the patients get used to room temperature, each breast was visualized at a distance of 2 m and then a total of 2 steady-state images from two directions including coronal plane view of mass and mirror-image site were taken. Thermal imaging process took approximately 10 s.

All images were analyzed using FLIR Quick Report 1.2 software program (FLIR Systems, Inc., North Billerica, MA, USA). Analysis can be made easily using this program either in numerical or graphical forms. For each lesion, 3 types of analysis were performed. Using "field" analysis tool, minimum, average and maximum temperature values of lesion site and mirror image site were measured and differences (ΔT1, ΔT2, ΔT3, respectively) were used as a measure of thermal symmetry. Thermograms exceeding 0.5 °C difference were categorized as asymmetric and abnormal.

Subsequent to thermal imaging, all patients underwent US examination. Radiologists measured the lesion size in the breast US in which the lesion manifested its greatest dimension. For patients aged above 40 years, mammographic examination was performed upon clinician request. After clinical and radiological examination, suspicious lesions were biopsied (ultrasound guided core needle biopsy). Results of thermal imaging according to the above-mentioned criteria was compared with histopathological results.

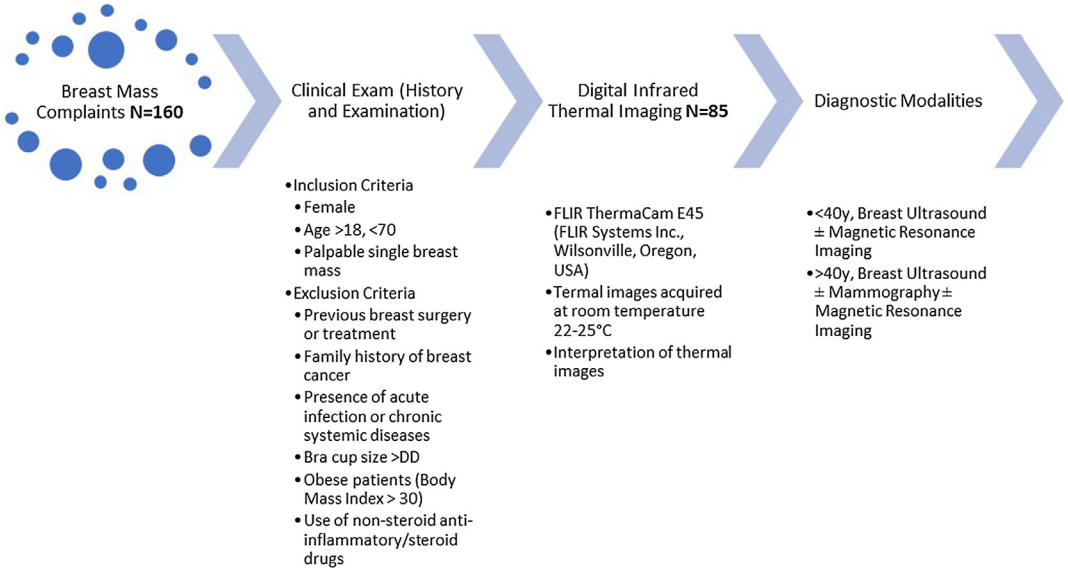

Fig. 1. The flowchart showing experimental process.