Differentiation between benign and malignant breast lesions using Multispectral Optoacoustic Tomography (MSOT)

Breast cancer is the most common malignant disease in women. While survival rates have recently significantly improved, diagnostic methods like mammography and ultrasound (US) are still flawed by limited accuracy. MSOT, which combines the benefits of optical and US imaging, could provide an alternative. Researchers have used MSOT in two diagnostic imaging approaches to assess lesion malignancy: 1) analyzing patterns of optoacoustic signal distribution and intensity; 2) quantifying optoacoustic signal enhancement by specific tissue chromophores. The results of these studies suggest a superior diagnostic performance of MSOT over mammography and US.

Assessing image patterns in malignancy

In a reader study of 94 female patients with either benign, indeterminate or suspicious breast lesions, MSOT was compared to mammography and ultrasound [1]. Signs were derived from a training set (34 patients). Readers were trained for 20 minutes, and then the remaining patients were assessed. MSOT could be used to differentiate benign and malignant breast disease. In comparison to the other imaging modalities, MSOT showed higher sensitivity (MSOT: 97%; mammography: 90%; US: 97%) and especially higher specificity (MSOT: 85%; mammography: 75%; US: 50%) in classifying lesions and could thus potentially improve diagnostic accuracy significantly.

INNOVATIVE
Provides high-resolution optical tissue contrast at depth, thereby potentially exceeding sensitivity and specificity achieved by other imaging modalities.

NON-INVASIVE
Enables real-time point-of-care lesion assessment without the need for radiation or application of contrast agents.

HIGH PERFORMANCE
Acquires images of breast tissue with spatial resolution down to 200 µm, with superior sensitivity and specificity for detecting malignant breast cancer as compared to mammography or ultrasound.

EASY TO USE
Similar workflow as in ultrasound examinations; with only a short tutorial, enables radiologists to recognize characteristic lesion features in MSOT images.

IMAGING PROTOCOL

Imaging System	MSOT Acuity Echo
Repetition Rate	25 Hz
Excitation Wavelength	700, 730, 760, 800, 850 and 900 nm.
Processing Methods	Back-projection tomographic image reconstruction; spectral unmixing by linear regression.

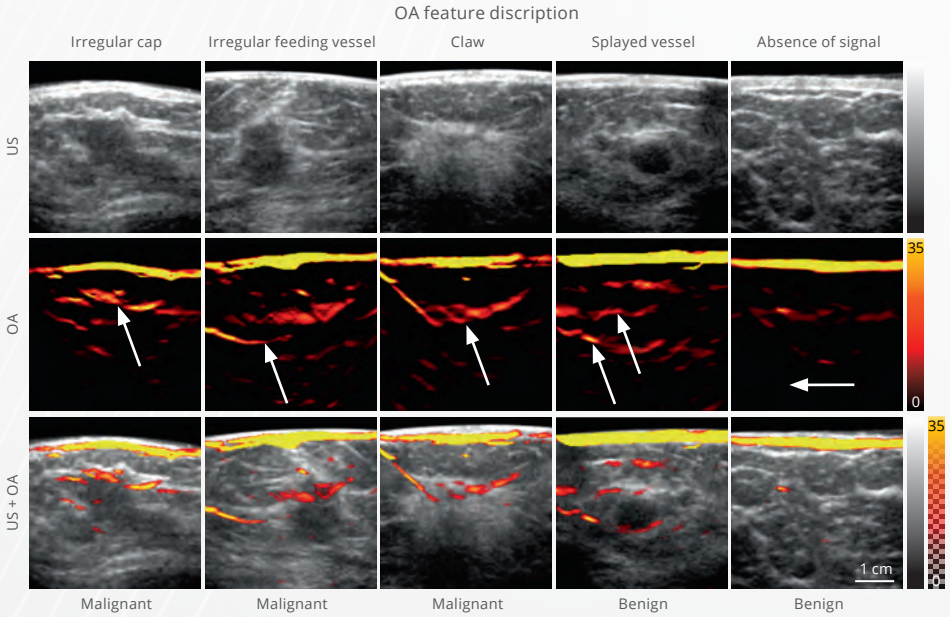

FIGURE 1: Using a radiologist's approach to analyze patterns of MSOT contrast

MSOT measurements for patients with benign and malignant breast cancer as determined by diagnostic standards. (US) Ultrasound measurements. (OA) Corresponding MSOT images. (US+OA) MSOT results shown as color-coded maps overlaid on ultrasound images. Three signs (irregular cap, irregular feeding vessel and claw) were associated with malignant tumors, while two signs (splayed vessels and absence of signal) were associated with benign lesions.

Quantitative differentiation of malignant versus benign breast tumors

Change in vasculature and tissue oxygenation are hallmarks of cancer. With contrast based on blood, water and lipid, MSOT signals are enhanced by cancerous lesions [2,3]. This allows for noninvasive insights into breast cancer vascularity and tissue composition without the need for exogenous contrast agents. Whereas optoacoustic signal in healthy breast tissue is homogenous, cancerous tissue is characterized by heterogeneity. Quantification of optoacoustic signals offers an additional endpoint that can complement existing diagnostic tests.

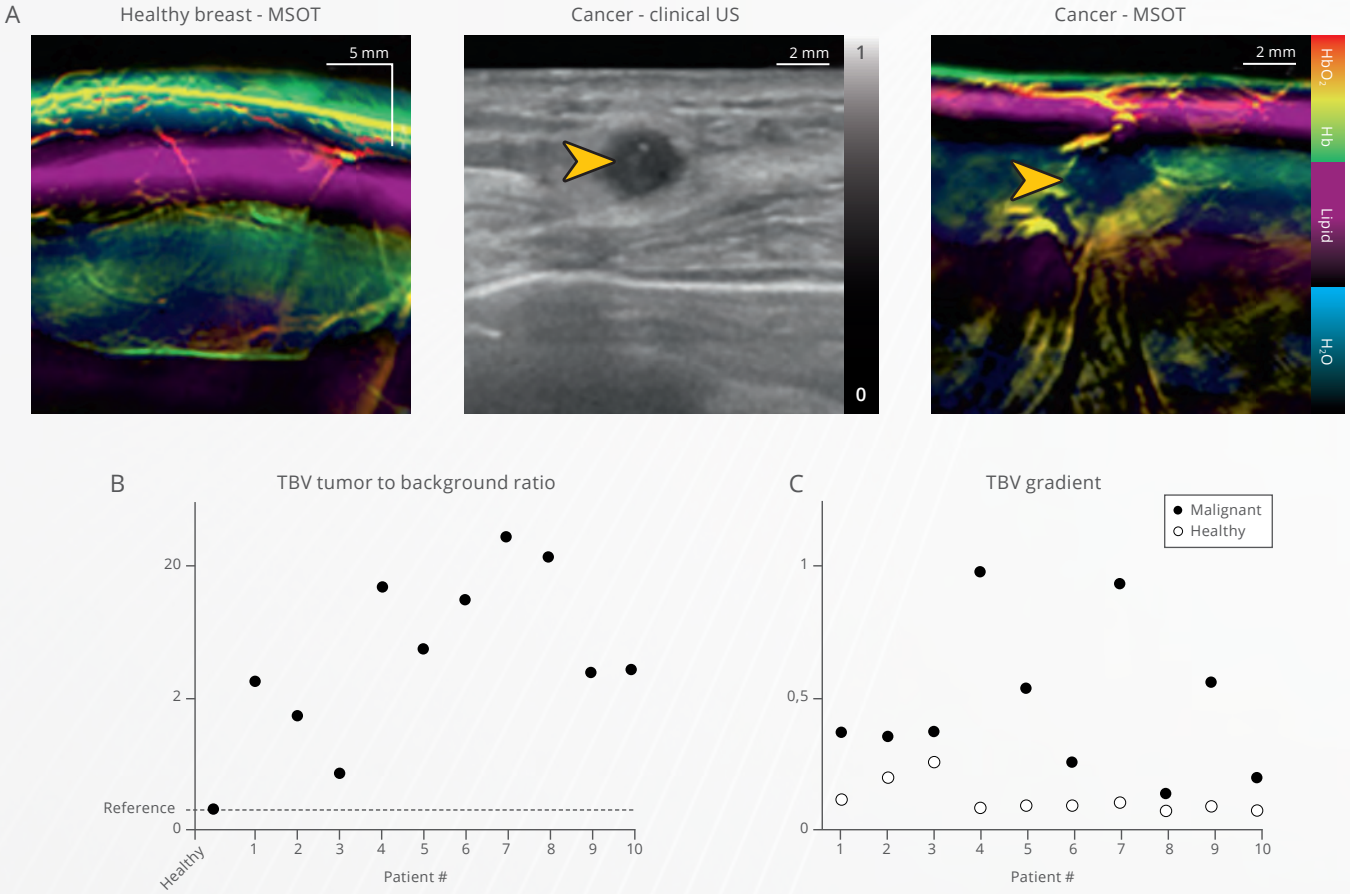

FIGURE 2: Enhancement of MSOT signal intensity in cancerous breast tissue.

Panel A shows merged composite images obtained by MSOT of healthy breast tissue and a non-specific malignant breast cancer lesion; ultrasound (US) image of the lesion as reference. Panel B shows total blood volume (TBV) measurements in healthy versus malignant cases in the entire region of interest. Panel C expresses TBV as a gradient from the outside to the inside of the lesion.

1. Abeyakoon O et al., **Optoacoustic imaging increases the sensitivity of mammography and specificity of ultrasound: implications for clinical practice,** in preparation.
2. Diot G et al., **Multispectral Optoacoustic Tomography (MSOT) of Human Breast Cancer,** Clin Cancer Res. 2017 Nov 15;23(22):6912-6922.
3. Becker A et al., **Multispectral optoacoustic tomography of the human breast: characterisation of healthy tissue and malignant lesions using a hybrid ultrasound-optoacoustic approach,** Eur Radiol. 2018 Feb;28(2):602-609.