Fabrication of a Realistic Breast Phantom Based on 3D Printing Technology for Thermoacoustic Imaging Application in Breast Cancer Detection

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As a hybrid mechanism integrating the advantages of microwave imaging and ultrasound imaging, such as non-ionizing radiation, high dielectric contrast and excellent spatial resolution, microwave-induced thermoacoustic imaging (TAI) holds promise for breast cancer detection (R. A. Kruger *et al*, Radiology, 216, 279-283, 2000).

Experimental results obtained with patients or using simple breast phantoms and computational studies employing realistic numerical breast phantoms have been reported. But none of these frameworks represents a suitable testbed for advancing TAI research in terms of developing and evaluating novel techniques. For example, exact knowledge of the tissue property and distributions in patients' breasts are not available. Utilizing a simple structured phantom fails to mimic a complicated realistic environment. Simulations can incorporate numerical breast phantoms with a high degree of resemblance to realistic ones, but they are not considered as ultimate corroboration of TAI.

Thus, fabricating a breast phantom with not only accurate material properties but also reasonable complexities in the interior structures is very useful in experimental validation of potential new techniques and imaging algorithms for TAI for breast cancer detection in a preclinical context. By this means, faithful comparison between simulations and experiments is enabled. Although the making of tissue-mimicking materials with accurate predefined dielectric properties is established in some reported recipes, the realization of predefined realistic anatomically complicated tissue structures in phantoms specifically for TAI has not been discussed in literature.

This work proposes a novel method for fabricating a realistic breast phantom with predefined complicated tissue structures with the aid of polymer jetting 3D printing technique. It contains four different types of tissue-mimicking materials representing breast fatty, glandular, transitional and tumor tissues. Molds are printed to achieve the complexity of the geometries of different tissues. This fabricated breast phantom is superior to those used in previous TAI works in terms of structure complexity, tissue diversity and most importantly the exact knowledge of the structure and material properties of the phantom.