ABSTRACT

Microwave imaging is an emerging medical imaging modality, which we propose for the diagnosis of Axillary Lymph Nodes (ALNs) in patients affected by breast cancer. In this study, we produced an anatomically and dielectrically realistic model of the axillary region to enable the experimental assessment of axillary imaging using microwave imaging technology. To do so, we segmented a thoracic Computed Tomography (CT) scan and we created a computer model representative of the anatomical configuration of the axillary region. We 3D printed the phantom in parts representing the organs of interest of the axillary region for the purpose of microwave imaging: ALN, fat, muscle, bone, and lung. We 3D-printed cavities to represent the fat, muscle, ALN, and lung and we filled them with appropriate liquids which mimic the dielectric properties of the tissues. The bone is made of solid conductive polymer which well mimics its dielectric properties. The phantom will be used for pre-clinical assessment of axillary microwave imaging.

INTRODUCTION

- Breast cancer is the most common cancer among women [1].
- Axillary Lymph Nodes (ALNs) drain up to 75% of the lymph from the breast.
- Lymphatic system is a potential vehicle for breast cancer metastasis.

ALN diagnosis

- significant prognostic factor
- crucial for guiding treatment planning

Current ALN diagnosis methods

- Ultrasound-Guided Biopsy;
- Computed Tomography (CT);
- Magnetic Resonance Imaging (MRI);
- Positron Emission Tomography (PET).

However, SNLB is invasive and may lead to health complications [2], such as:
- damage of blood vessels and nerves;
- incision infection;
- lymphedema.
In addition, more than 50% of early-stage invasive breast cancer patients have no ALN metastasis, meaning that SNLB is unnecessary in those cases [3].

There is a clear need of non-surgical alternatives to SNLB.

Microwave imaging

is an emerging, non-invasive, and low-cost imaging modality which we propose for ALN diagnosis.

In axillary microwave imaging:

- the patient lies a supine position, with her arm extended along the head.
- an antenna roto-translates around the axilla, thus illuminating the ALNs and collecting their microwave backscattered signals from multiple perspectives.

In order to assess the feasibility of axillary microwave imaging, an anthropomorphic model (i.e. a phantom) of the axilla is needed.

PHANTOM DEVELOPMENT

1) CT scan segmentation

Segmentation of the 4 organs of interest: muscle, bone, lung, and fat.

2) 3D modelling

- Creation of cavities and apertures for fat, muscle, and lung organs (from most external to most internal container). The apertures enable filling the cavities with the appropriate tissue mimicking liquid (further explanation in Step 4).
- Creation of holding part which ensures the organs are static and in a consistent position.

3) 3D printing

4) Tissue mimicking liquid fabrication

- Fabrication of liquid mixtures (made with the same methodology as in [4]) which have similar dielectric properties (relative permittivity and conductivity) to those of the mimicked biological tissue;
- The tissue mimicking liquid are used to fill the cavities of the corresponding 3D-printed organ container.

CONCLUSIONS

- We developed a 3D printed phantom that is anatomically realistic and it has similar dielectric properties to those of axillary tissues.
- We plan to use the developed phantom to experimentally validate microwave imaging as a valuable method for the imaging of the axillary region.

REFERENCES