Acquisition of multiple mode shear wave propagation in transversely isotropic medium using dual probe setup

Gioia Bassan[1], David Larsson[1], Tim Nordenfur[1], Anna Bjällmark[1], Matilda Larsson[1]
[1]*Department of Medical Engineering, School of Technology and Health, KTH Royal Institute of Technology,Alfred Nobels Allé 10, 14152 Huddinge, Sweden.*

1. Background

Shear Wave Elastography (SWE) is a novel ultrasound-based technique for estimating regional mechanical properties of soft tissue. By measuring the propagation velocity of acoustically initiated shear waves, the tissue elasticity can be derived by assessing the regional speed of the propagating shear waves. However, in commercial systems, the wave propagation analysis have so far been limited to assumptions of infinite and isotropic medium, with such neglecting the complex wave behaviour in non-isotropic biological tissue. In recent years, research studies on SWE analysis in non-infinite and non-isotropic tissue have been performed, however so far with most work focusing on either theoretical analysis of SWE propagation [2] or feasibility trials in pre-defined tissue structures [3]. The aim of this study has therefore been to evaluate the general ability of using SWE to experimentally retrieve multiple transversely isotropic (TI) elasticity measures in a generic transversely isotropic phantom.

2. Method

A TI phantom was made of a water solution with 7%wt of Polyvinyl Alcohol (PVA) and 3%wt of graphite. The phantom underwent two freeze-thaw (FT) cycles, after which it was stretched to 160% of its initial length (Fig. 1(a)) for three additional FT cycles. Stretching induces transverse isotropy [1]. Mechanical axial tests were performed to characterize the elastic moduli in perpendicular and longitudinal direction, respectively. SWE was performed using a programmable ultrasound system (V1, Verasonics Inc, Redmond, WA, USA) with two 128-element linear transducers (L7-4, Philips Healthcare, Andover, MA, USA) in a dual-probe setup (Fig. 1(b)). In each of the two shear wave modes present in TI media, pure-transverse (PT) and quasi-transverse (QT) [2], the shear wave group velocity was measured along 7 directions and deriving the others 5 from symmetry properties. The propagation speeds were compared to theoretical results [2].

3. Results

Fig. 1(c) shows the measured shear wave speeds in PT (red crosses) and QT (blue circles) modes, as well as theoretical propagation speeds in PT (solid red lines) and QT (dashed blue lines). The empirical and theoretical results show good agreement for both wave modes.

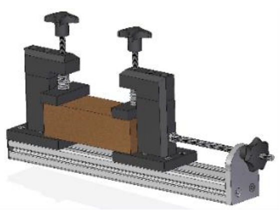

Figure 1(a): Set-up for the stretching

Figure 1(b): Set- up for the Dual Probe

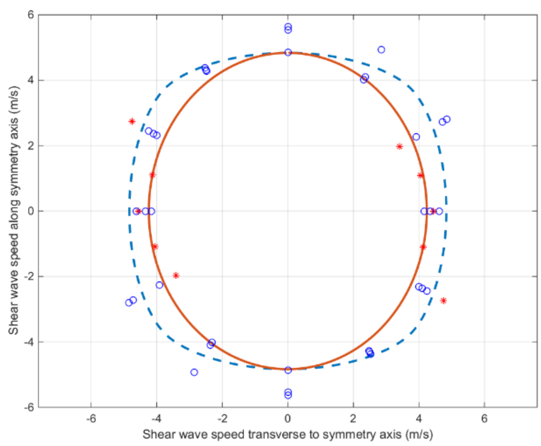

Figure 1(c): PT (red) and QT (blue) theoretical propagation modes compared with the velocity estimated using one (red asterisk) and two (blue circles) probes.

4. Discussion

In the following work, we present a way of assessing multiple wave mode acquisition using SWE and a novel dual-probe setup. Initial phantom tissue results indicate a good agreement between experimental data and theoretical predictions, indicating the ability of using SWE as a measurement tool for more complex analysis of mechanical behaviour even for transversely isotropic tissue.

5. References

[1] Chatelin et al. *Phys in Med & Bio*, 2014, 59(22), doi: 10.1088/0031-9155/59/22/6923
[2] Palmieri et al. *J Biomech*, 2013, 46(16), doi: 10.1016/j.jbiomech.2013.09.008
[3] Gennison et al, Ultrasoun in Med & Biol, 38(9), doi: dx.doi.org/10.1016/j.ultrasmedbio.2012.04.013