Analysis of Motion in Human Thyroid: Longitudinal and Transverse Cross Sections for SVD Based Small Vessel Power Doppler Imaging

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Microvascular imaging can be a valuable tool for non-invasive diagnosis of thyroid lesions, towards preventing unnecessary biopsies. However, motion in the thyroid due to its proximity to the pulsating carotid artery (CA) can impact coherent integration of the power Doppler (PD) ensemble, and affect visualization the blood flow signal, especially in small vessels. Given the anatomical arrangement of the trachea, thyroid and the CA, the motion of the thyroid is longitudinal cross-section (CS) is predominantly lateral, however, that in the transverse CS corresponds to out-of-plane motion [1, 2]. This information is valuable and relevant for thyroid PD imaging because motion in lateral motion can be corrected [1]. According, we hypothesize that imaging of longitudinal CS may be more efficacious for small vessel PD imaging of thyroid nodules.

We tested this hypothesis *in vivo* on 24 human thyroids. Compounded plane wave data was acquired for 3 seconds at >600 frames/sec. Data was acquired in both longitudinal and transverse CCs. Microvascular imaging, motion estimation and correction were performed [1]. Normalized cross-correlation (NCC) and motion compensated cross-correlation (MCCC) were used as measures of out-of-plane motion. SNR and CNR were computed as indicated in [1].

The results show that for all cases, transverse CS displayed lower NCC and MCCC, relative to the corresponding longitudinal CS. This is likely due to pixels going out of plane in the former. Lateral displacement plots show that for ~75% of cases displayed relatively higher lateral motion in longitudinal CS compared to transverse. Accordingly, improvements in signal-noise ratio and contrast-noise ratio upon motion correction were relatively higher in longitudinal CC. Accordingly, in the presence of motion, imaging of thyroid microvasculature in the longitudinal CC was more advantageous. These preliminary results were encouraging for further *in vivo* validation on a larger patient population.

[1] Nayak R. *et. al.* Non-contrast agent based small vessel imaging of human thyroid using motion corrected power Doppler imaging. *Scientific reports*, *8*(1), p.15318, 2018.
[2] Bae, U, *et. al.* Ultrasound thyroid elastography using carotid artery pulsation: preliminary study. *Journal of Ultrasound in Medicine*, *26*(6), pp.797-805, 2017.

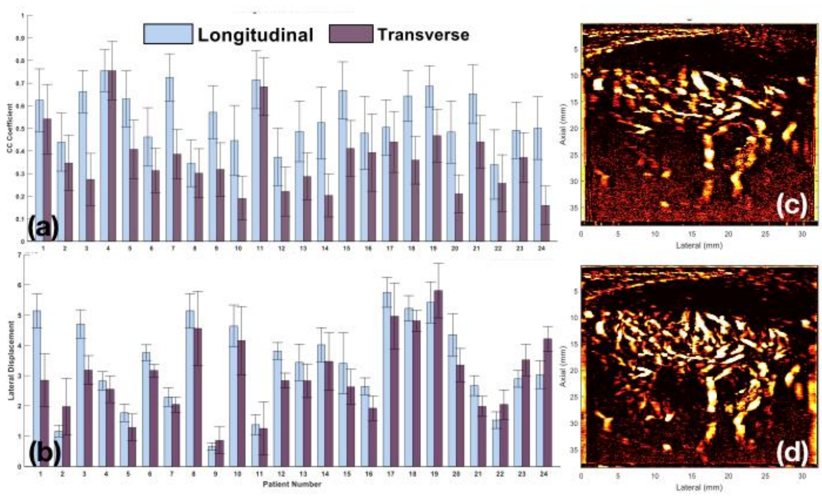

Fig. 1: (a, b) displays estimated mean NCC co-efficient and lateral displacements, obtained from the thyroid lesions in 24 patients, respectively. The NCC values (a) were in the range 0-1, and the lateral displacements (b) were reported in microns. (c, d) displays a representative PD images associated with thyroid longitudinal CS, before and after motion correction, respectively, with same color range. Improvements in visualization of microvessels in the motion corrected PD image (d) over (a) were noticeable.