This thesis elaborates the image processing steps (phase unwrapping and directional filtering) which are applied to the psoas major muscles in a stiffness imaging technique, known as MR elastography. Magnetic Resonance Elastography (MRE) is a dynamic MR imaging technique that can non-invasively quantify the biomechanical properties of soft tissues via the direct visualization and measurement of shear wave displacements, transmitted by using mechanical vibrations. MRE is an emerging and promising biomarker imaging tool for the early detection of alteration in biomechanical properties.

This thesis begins with the structure of muscles, skeletal muscle imaging and an introduction to MR elastography technique. A theoretical background regarding MR imaging and MR elastography is summarized. The fundamental concept of MRI and MRE was essential to understand the image acquisition in MRI imager and image processing steps, namely phase unwrapping and filtering, and elastogram reconstruction in MRE respectively. Phase unwrapping is an initial step for image processing in MRE. The four phase unwrapping algorithms, namely Minimum Discontinuity (MD), Laplacian-Based Estimate (LBE), Region Growing (RG) and Dilate-Erode (DE) propagate were applied to psoas major image data. MD and LBE could successfully unwrap the phase wrapped images. However, LBE yielded higher phase amplitude than MD and is recommended for phase unwrapping of psoas major
MRE data. Image filtering is the second step of image processing in MRE. Image filters, namely gaussian bandpass, directional filter and combined directional-bandpass filter was applied to the phase unwrapped psoas major image data. Among all three filters applied, results showed that the directional-bandpass filter was best suited for psoas major image filtering, since it removed wave interferences, high frequency noise components and low frequency longitudinal waves and bulk motion effects. Hence, the directional-bandpass filter could potentially yield accurate elastograms, rather than using individual filter. Two wave – inversion algorithms, namely Local Frequency Estimate (LFE) and Algebraic Inversion of Differential Equation (AIDE) were used for elastogram reconstruction. The stiffness value calculated by using LFE was significantly higher than the stiffness value calculated by using AIDE. Moreover, the stiffness output by using MD phase unwrapping algorithm was significantly higher than the stiffness output by using LBE phase unwrapping algorithm. However, we were unable to measure the stiffness of psoas major in vivo. So, we were unable to mention which wave – inversion and which phase unwrapping algorithm yielded accurate elasticity value of psoas major. Furthermore, a simultaneous MRE acquisition technique of psoas major (PM) and erecter spinae muscle (ESM) was developed in a conventional MRI imager. Previous literature stated that the motion-encoding gradient (MEG)-like effect was in AP direction for psoas major muscle, and in this study, the MEG-like effect was resulted in RL direction for erector spinae muscle. The AP 45° Motion-Encoding Gradient (MEG)-like effect direction at 50 Hz vibration frequency, incorporating directional filter during image processing can obtain displacement fields in both muscles, that can be used to measure stiffness of psoas major and erector spinae muscles simultaneously.