Deep learning-based segmentation and fat fraction analysis of the shoulder muscles using quantitative MRI

Background Tears of the rotator cuff tendons are a common cause of pain and reduced function of the shoulder. Surgical repair of tears has been related to significant short- and long-term improvements in pain score, function, and strength over the short and long term, providing a less invasive alternative to complete shoulder replacement. However, rates of surgical complications and re-tear of repaired tendons are high (30% – 57%). Atrophy and fatty muscle degeneration influence overall outcome and strength and may predict the results of rotator cuff repair. Qualitative and subjective visual inspection categorisations of fat fraction percentage remains a standard clinical influencer of repair suitability (Fuchs 1999) despite studies suggesting that quantitative measures would provide more accurate results (Lee 2013). Dixon MRI provides muscle/fat separation and quantitative fat/muscle information; however, the protocol is not routinely available in clinics.

Aim To investigate deep learning-based segmentation methodologies for the shoulder muscles and deep learning-based fat fraction analysis that allows quantitative analysis from standard T1 images based on state-of-the-art quantitative MRI.

Materials and Methods Based on an existing series of corresponding quantitative multi point Dixon and T1 MR images, deep learning-based segmentation algorithms for the shoulder muscles will be developed based on existing network (Zeng 2018). The algorithms will be validated for accuracy and robustness and integrated into existing surgical planning software. Automated algorithms for the calculation of muscle volume, fat fraction and volume adjusted for fatty infiltration will be developed and integrated into the software system. Dixon images will be used to train a network to quantify the fat content of the segmented muscle more accurately from standard T1 diagnostic images. The functionality will form part of a complete system for the diagnosis, treatment planning and treatment outcome prediction of rotator cuff repair and the work will be conducted in collaboration with clinical partners within the departments of orthopaedic surgery, radiology and neurology.

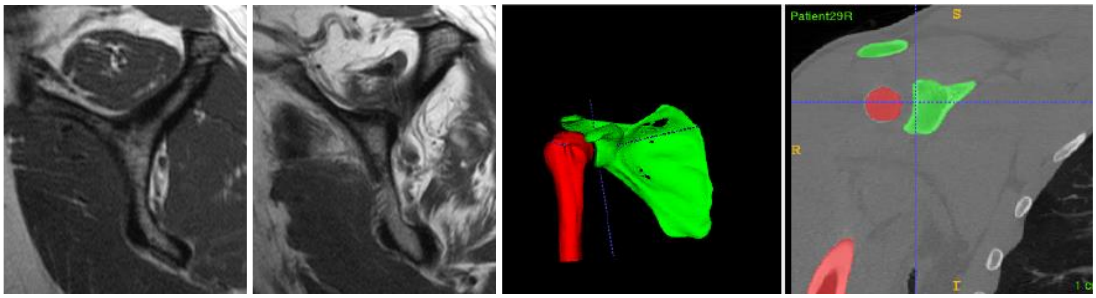

Fig 1. Fatty infiltration of the shoulder muscle in MRI (left) and automated segmentation of the shoulder bones in CT (right)

Nature of the Thesis:
Image analysis: 60%
Software development: 40%

Requirements:
Python and C++
Interest in artificial intelligence, image analysis, clinical software development

Supervisors
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Institutes:
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References:

Fuchs et al., Fatty Degeneration of the Muscles of the Rotator Cuff: Assessment by Computed Tomography versus Magnetic Resonance Imaging. Journal of shoulder and elbow surgery 8(6):599–605, 1997.

Lee et al., Fatty Degeneration of the Rotator Cuff Muscles on Pre- and Postoperative CT Arthrography (CTA): Is the Goutallier Grading System Reliable?, *Skeletal Radiology* 42(9):1259–67, 2013.

Zeng et al., Latent3DU-Net: Multi-Level Latent Shape Space Constrained 3D U-Net for Automatic Segmentation of the Proximal Femur from Radial MRI of the Hip, Pp. 188–96, *MLMI 2018*

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