Automated quantification of massive rotator cuff tears from 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 have been reported to occur in more than 30% of cases and for more technically difficult repair of larger (massive) rotator cuff tears, re-tearing occurs in as many as 57% of cases. The diagnosis of rotator cuff tears and rotator cuff repair (RCR) risk factor analysis relies on the parametrisation of shoulder morphology and tissue composition from medical image data. Important diagnostic parameters linked to repair success, such as the tear size and shape, are typically measured manually on a single 2D image slice (Morag 2006). Thus, accuracy of measurements currently relies on observer interpretation and how representative the selected image slice is of the 3D anatomical structure. An accurate 3D analysis of the tear could aid in surgical planning, surgical outcome prediction and assist the surgeon in treatment decision making.

Aim The student will investigate deep learning-based segmentation methodologies for the tendons of the shoulder along with methodologies for automatically identifying and parametrising a tear.

Materials and Methods Based on MRI datasets of the shoulder, deep learning-based segmentation algorithms for the shoulder tendons, that allow differentiation from the connecting muscle, will be developed based on existing networks (Zeng 2018). Automated algorithms for identification and parametrisation of a tear in the tendon will be developed and validated for accuracy and robustness against manual annotation. The developed algorithms will be implemented into an existing surgical planning system for the diagnosis, treatment planning and treatment outcome prediction of rotator cuff repair. The work will be conducted in collaboration with clinical partners within the departments of orthopaedic surgery, radiology and neurology.

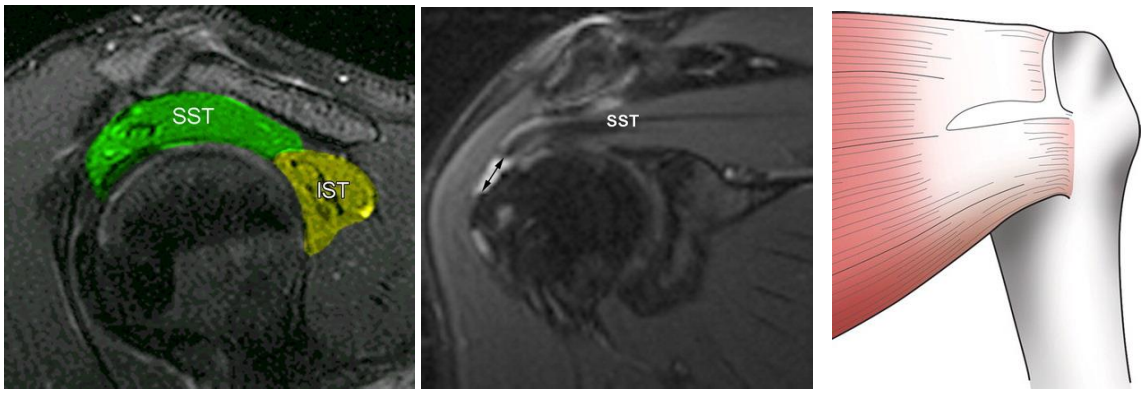

Fig 1. Segmented supraspinatus (SST) and infraspinatus (IST) tendons (left). Full thickness of the SST tendon tear in T2 weighted MRI (middle). Illustration of a U-shaped tendon tear (Morag 2006) (right).

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:
Morag et al., MR Imaging of Rotator Cuff Injury: What the Clinician Needs to Know, Radiographics, 26:4, 2006
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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