Bern, 13.04.2021

b UNIVERSITÄT BERN

Bern Data Science Day 2021 - April 23

Contribution - Machine learning and patient-specific biomechanical methods for assessing outcome in total shoulder arthroplasty

DS applications and challenges in Medicine, Natural Sciences, and Engineering

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Abstract

Glenohumeral osteoarthritis is increasing worldwide, as in Switzerland, because of the aging population. Total shoulder arthroplasty (TSA) is becoming a common surgical procedure intended primarily to relieve pain and disability associated with glenohumeral osteoarthritis and restoring the range of motion. However, the success rate of TSA remains poor compared to other main total joint replacements such as hip or knee. There is a lack of clear indicators able to predict the long-term success of TSA. The complex biomechanical configuration of the glenohumeral joint could explain this and potential causes for the observed complications have been proposed, such as the pre-surgical state of rotator cuff muscles, the shape/orientation of the degenerated glenoid cavity, or the bone quality. Thus, we propose image analysis and deep learning-based approaches to quantify all potential preoperative mechanical markers and identify the ones that are critical to the success of TSA. In this regard, we implemented a Convolutional Neural Network (CNN) based segmentation of healthy and pathological scapulae in axial Computed Tomography (CT) scans or 3D volumes of these axial CT scans. Moreover, based on these segmentations, we are currently working on detection of landmark points on scapulae to determine several morphometric parameters that can potentially be related to TSA outcome, such as glenoid orientation, acromion index and critical shoulder angle. To predict the landmark points, we investigate two different approaches. First approach implemented is utilization of a similar CNN as in segmentation module and prediction of distance maps that demonstrate the geodesic distance between the landmarks and each voxel of the bone segmentation. An alternative approach implemented to determine the landmark points is prediction of these distance maps directly on the surface meshes by utilizing Graph Neural Networks. We also aim to estimate pre-morbid states of muscles and bones in the shoulder with deep learning-based approaches, as well as investigate micro-CT images to understand bone anisotropy and predict the best implant position based on different markers that will be investigated throughout the project.