

Background:

Analyzing motion in the spine remains a challenge. Spinal motion is commonly analysed through segmental range of motion (sROM). However, this method shows high intra- and inter-individual variability. In a previous study by our group, motion patterns in radiographic recordings of flexion and extension were investigated. Contours of the occiput (C0) and cervical vertebrae (C1-C7) were manually drawn and corrected, which is very labor-intensive. The present study uses the annotated data to train two deep learning segmentation models to recognize and track cervical vertebrae.

Methods:

Radiographic flexion-extension recordings of healthy volunteers and pre-operative patients with cervical degenerative disc disease were used. C0-C7 were manually annotated in all successive frames of the recordings. In order to achieve the localisation of vertebrae across multiple frames, two segmentation approaches were developed using ResUnet++ network and Mask-RCNN. The ResUnet++ network was trained for segmentation of C4-C7 on 5720 images and validated in 520 images. The Mask-RCNN model was trained on 2025 images and validated in 176 images for C0-C7.

Results:

The AI-models almost exactly identify cervical vertebral contours (Fig. 1). The ResUnet++ network predicts C4-C7 accurately when compared to the ground truth (Fig. 1a-c). The Mask-RCNN model obtained good segmentation of C0-C7 in the majority of cases (Fig. 1d). In a few cases, C7 could not be adequately detected in full due to overprojection of the shoulder.

Discussion:

These AI-assisted algorithms enable time-efficient and accurate segmentation of C0-C7. Moreover, human experience and training is not required. The accessibility of this method allows more extensive analysis of spinal motion, of which in depth knowledge is currently still lacking. The next steps will be to further validate the model with recordings of patients with anatomical variants or implants in-situ. Ultimately, the aim is to investigate the relationship between motion of the cervical spine and the development of pathology. Figure legend: 1a Original lateral X ray cervical spine. 1b Identification C4-C6 by observer (radiologist) 1c Identification C4-C6 by AI 1d Identification of C0-C7 by AI

