Image Segmentation and Analysis of Flexion-Extension Radiographs of Cervical Spines

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Introduction

Despite frequent use, flexion-extension radiographs remain difficult to interpret. Automatic image segmentation and identification of anatomical landmarks has the advantage of eliminating the subjectivity in image analysis. We present a novel analysis tool for determining cervical instability on flexion-extension radiographs based on machine vision and computerized image processing.

Methods

Ten de-identified flexion-extension radiographs were obtained from the treating physician of patients who underwent cervical spine fusions at the University of Arizona Medical Center. We used semi-automatic image segmentation with K-means clustering to detect the spinolaminar (SL) and anterior vertebral (AV) lines in each radiograph. The optimal number of clusters K and the mask Sj that results in the best segmentation were determined empirically (K {4, 5, 6} and j {K - 1, K - 2} for all processed images). Using acquired image points from the skull to the T1 spinous process, an algorithm extracting coordinates of the SL and AV lines was calculated in Matlab. The resulting curvatures were overlaid on corresponding radiographs, and a curve-fitting algorithm was applied, allowing for analysis of changes in spinal curvatures.

Results

The described computerized image segmentation method allows for quantitative analysis of changes in the curvature of the SL and AV lines in flexion-extention radiographs and identification of points of greatest curvature change. In this small sample, extension radiographs revealed larger curvature changes in the SL line, while flexion radiographs generated larger curvature changes in the AV line.

Conclusions

This novel tool for analysis of changes in cervical spine curvature may lead to more precise interpretation of flexion-extension radiographs, allowing for more accurate diagnoses of spinal instability or pseudoarthrosis in healing and presumptively fused spines.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Describe the novel technique of automatic image segmentation for the interpretation of flexion-extension radiographs of the cervical spine.

2) Discuss the importance of cervical spinolaminar and anterior vertebral lines in the interpretation of flexion and extension radiographs of the cervical spine.