Highlights:

- The 3D end-to-end pipeline had an area under receiver operating curve (AUROC) of 0.93 in detecting cervical vertebrae fracture.
- The per-vertebrae nature of the workflow enables precise localization of fractures, which can help expedite evaluation by expert radiologists to verify or reject the model's predictions.

Detecting and Localizing Cervical Spine Fracture Using an End-to-End 3D Deep Learning Pipeline

Bardia Khosravi, MD, MPH, MHPE[1]; Sanaz Vahdati, MD[1]; Pouria Rouzrokh, MD, MPH, MHPE[1]; Mana Moassefi, MD[1]; Shahriar Faghani, MD[1]; Bradley J. Erickson, MD, PhD[1]

1. Department of Radiology, Mayo Clinic, Rochester, MN

INTRODUCTION

Commercially available computer-aided diagnosis tools are being utilized to triage studies and prioritize patients with suspected cervical spine fractures. However, their effectiveness is limited in patients with coexisting degenerative diseases and osteoporosis, with reported sensitivity ranging from 54% to 76%. This study aims to develop a deep learning algorithm capable of reliably detecting and localizing cervical spine fractures in CT scans.

METHODS

Data from the RSNA Cervical Spine Fracture Challenge (n=2019) was used to train and validate the algorithm. This data was collected from twelve different institutions, allowing for the development of a more generalizable model. Taking inspiration from the holistic approach used by radiologists, an end-to-end 3D method was employed to avoid mistaking artifacts that mimic fractures in 2D slices, such as nutrition canals. A weakly supervised approach was initially used to localize the C1-C7 vertebrae by applying a trained model to the data and manually correcting masks for 400 studies. This was followed by training a segmentation model to fine-tune the segmentation masks. The segmented vertebrae were then cropped from the image and straightened along the z-axis to account for possible neck flexion.

Each 3D vertebrae volume was resized to 256x256x64 and used to train a 3D EfficientNetB4 to classify images as either with or without a fracture. The performance of the segmentation model is reported on an internal test set with human-annotated ground truth. We used 5-fold cross-validation to develop a more robust classifier and reported the ensemble results.

RESULTS

The segmentation model achieved a Dice Similarity Coefficient of 0.93. The vertebrae-level fracture detection model had an area under the receiver operating curve (AUROC) of 0.92. When combined in an ensemble on a patient level, the model achieved an AUROC of 0.93 with a sensitivity of 87% and specificity of 77%.

CONCLUSION

This work presents a 3D deep learning model for detecting and localizing cervical spine fractures in CT scans from multiple institutions. The high sensitivity of the model makes it suitable for screening purposes. Additionally, the per-vertebrae nature of the workflow enables precise localization of fractures, which can help expedite evaluation by expert radiologists to verify or reject the model's predictions.

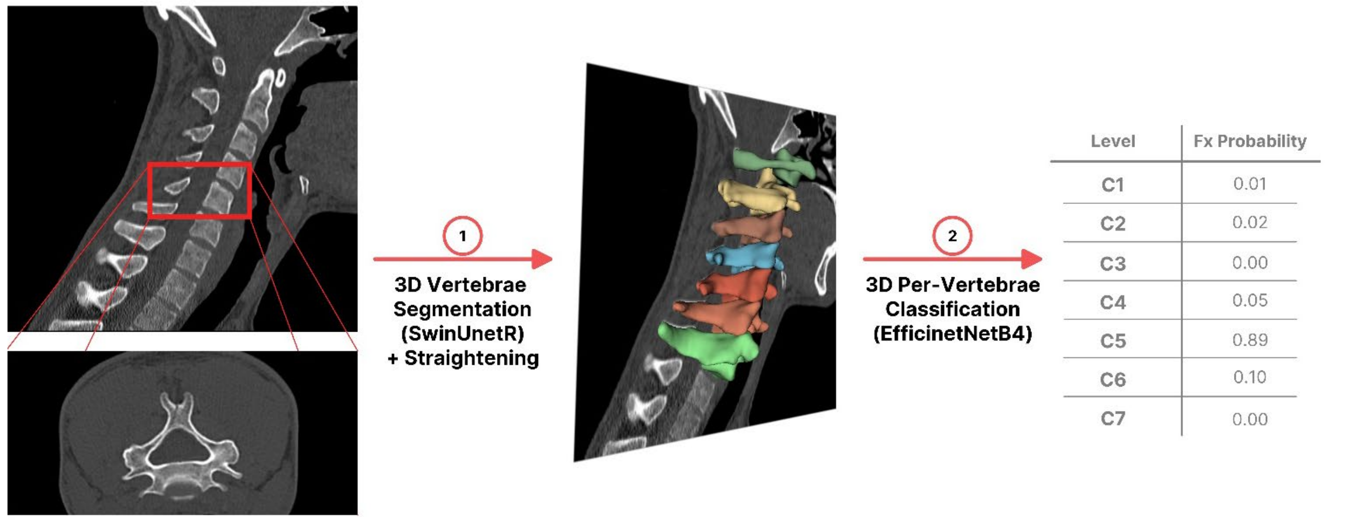

Figure. Overview of the fracture detection pipeline.

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CONTACT US

Bardia Khosravi, MD: khosravi.bardia@mayo.edu

Bradley J. Erickson, MD PhD: bje@mayo.edu