Development and Validation of an Automated Pipeline for the Detection of Monteggia Fractures in Pediatric Radiographs

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INTRODUCTION: Monteggia fractures are a complex elbow injury that is missed in up to 50% of pediatric patients during initial radiographic assessment due its subtlety. Missed or delayed diagnosis can lead to long-term complications like chronic pain, deformity, and loss of mobility. The development of more advanced diagnostic tools is crucial to prevent these complications and ensure appropriate treatment for patients. This study aimed to develop and internally validate an automated pipeline that accurately identifies Monteggia fractures by quantifying radial head displacement on elbow radiographs and detecting ulnar fractures on forearm radiographs.

METHODS: The automated pipeline utilizes a two-step, deep learning approach to detect both characteristics of a Monteggia fracture. First, to identify radial head dislocation, 320 pediatric anteroposterior (AP) and lateral elbow radiographs were used to train a U-Net++ neural network to segment the capitellum and radial neck. Model performance was evaluated using the Dice coefficient and the intersection over union (IoU). The outputs of this model were used to algorithmically construct the radiocapitellar line and measure its displacement from the capitellum. Second, a binary classifier was trained on 72 paired AP and lateral radiographs to detect the presence of ulnar fractures.

RESULTS: The first model displayed high accuracy for the segmentation of both the capitellum (Dice: 0.878 ± 0.098; IoU: 0.794 ± 0.130) and radial neck (Dice: 0.912 ± 0.105; IoU: 0.852 ± 0.142). The model achieved an Area Under the Curve of 0.958 for the detection of lateral radial head displacements and 0.971 for AP displacements. Across both views, the model identified radial head dislocations with an accuracy of 92.3%, sensitivity of 81.8%, and specificity of 96.4%. The binary classifier efficiently identified ulnar fractures with an accuracy of 88.9%, sensitivity of 100%, and specificity of 50.0%. When used in tandem on 6 grouped elbow and forearm radiographs, the models identified Monteggia fractures with an accuracy of 83.3%.

DISCUSSION AND CONCLUSION: This study introduces an automated pipeline for the detection of Monteggia fractures in pediatric radiographs. By combining segmentation-based measurement of radial head displacement with binary detection of ulnar fractures, the pipeline achieved high overall accuracy and sensitivity. The model's ability to detect subtle radiographic findings with performance metrics comparable to expert interpretation highlights its potential as a clinical decision support tool.