Utilizing Deep Learning to Automatically Measure Radiographic Parameters for Individuals with Distal Radius Fractures

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INTRODUCTION: The principal aim of this study was to evaluate whether artificial intelligence (AI) algorithms would be capable of identifying relevant anatomy from wrist radiographs to automatically measure commonly used radiographic parameters. We hypothesized that a deep learning-based segmentation model could accurately identify the radius and ulna in radiographs of individuals with distal radius fractures, enabling automated calculations of key radiographic parameters—radial inclination, volar tilt, and ulnar variance. This automation could facilitate large research studies and ease radiographic assessment of fractures.

METHODS: A convolutional neural network-based segmentation model built using a UNet architecture was developed and trained on radiographs of distal radius fractures. 1,096 patients (769 male, 300 female) were included and were split into training, validation, and test datasets using a 70-15-15 split. Segmentations and measurements for radial inclination, volar tilt, and ulnar variance were manually conducted on posteroanterior (PA) and lateral radiographs to compile a database for training the deep learning model and evaluating its accuracy. Following segmentation, an automated pipeline employing contour analysis, skeletonization, and morphological processing was used to extract three radiographic parameters: radial inclination, volar tilt, and ulnar variance.

RESULTS: The segmentation model achieved a dice score of 0.98 for PA radius segmentation, 0.98 for PA ulnar segmentation, and 0.95 for lateral radius segmentation. Automated measurement for radial inclination achieved a mean absolute error (MAE) of 3.35, a median absolute error of 1.91, and a root mean squared error (RMSE) of 5.89. Benchmarks for volar tilt were 8.60, 2.97, and 21.9 and ulnar variance were 2.60, 0.834, and 8.42 for the same metrics, respectively. Excluding outliers (<10 samples) where the initial image segmentation model did not fully capture the necessary anatomical landmarks, leading to inordinate measurements, the automated radial inclination measurement achieved an MAE of 2.75 and RMSE of 4.32, volar tilt measurement achieved MAE of 3.92 and RMSE of 5.6, and ulnar variance measurement achieved MAE of 1.36 and RMSE of 2.53.

DISCUSSION: This study was conducted as a proof of concept and demonstrates the feasibility of automating radiographic parameter extraction, potentially aiding clinicians in rapid radiographic assessment of fractures as well as future research. A segmentation model was successfully developed to isolate the radius and ulna in distal radius fracture radiographs and automated measurement of radial inclination, volar tilt, and ulnar variance was implemented and evaluated. Future work aims to expand the system to include additional parameters for a more comprehensive assessment of fracture stability.

SIGNIFICANCE/CLINICAL RELEVANCE: By reducing the need for manual measurement, this approach can improve efficiency in fracture assessment, minimize interobserver variability, and enable rapid, standardized evaluation across large patient cohorts. Such tools could support both clinical decision-making and large-scale research studies aimed at improving outcomes in distal radius fracture management.

Figure 1. Automated Segmentation Overlayed on Original Image

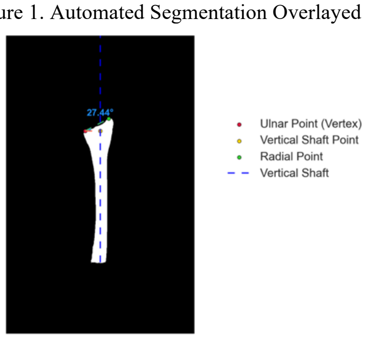

Figure 2. Radial Inclination Automated Measurement