A Convolutional Neural Network to Predict Surgical Versus Nonsurgical Management of Acute Isolated Distal Radius Fractures in Patients Under Age 60

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INTRODUCTION: Distal radius fractures (DRFs) represent up to 20% of fractures seen in the emergency department (ED)1; delays in the operative management of DRFs after their initial ED visit are often related to diagnostic uncertainties and a lengthy referral and triage process. These delays are associated with increased complexity of surgical procedures, longer operative time, increased complications rates, and poorer patient reported functional outcomes2–4. To address this challenge at our institution, we aim to create a convoluted neural network capable of automating DRF x-ray analysis. We hypothesize this model will accurately predict whether an acute DRF fracture will require operative management or non-operative management based on radiographic input alone.

METHODS: Using institutional EMR, x-rays of patients who presented to the ED (from 2018 to 2023) with a DRF and who were subsequently referred to the Fracture Clinic and/or the Hand Clinic were selected. 169 patients treated surgically and 169 patients treated non-surgically were included. X-rays taken during their acute injury period (within 4 weeks) in various radiographic positionings were collected for both groups and labeled as either pre-reduction or post-reduction. A total of 2733 scans were pre-processed for model training with the following techniques: segmentation to isolate the region of interest, histogram equalization for enhanced quality and brightness, and adjusted aspect-ratio with subsequent resizing for standardization. Using a 2x2 confusion matrix, values for True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) were calculated (Figure 1). Evaluation of performance metrics were then assessed including sensitivity, specificity, accuracy, precision, positive and negative predictive values. The gold standard for diagnosis equivalence was the surgeon's clinical decision of treating the patient operatively or nonoperatively.

RESULTS: Preliminary image classification performance metrics are reported in Table 1. When using all available radiographs, the model predicted with 91% accuracy whether an acute DRF would require operative or non-operative management. The model is still being optimized; updated and complete performance metrics are projected to obtained by the end of June 2024.

DISCUSSION AND CONCLUSION:

A convolutional neural network-based algorithm can predict with 91% accuracy whether an acute DRF fracture will require operative management or non-operative management based on radiographic input alone. Machine learning can improve patient outcomes by immediately identifying patients likely to require operative management and directing them through expedited surgical care pathways.

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Figure 1.		**Historical Patient Data as the standard of reference**	
		Treated Operatively	Treated Conservatively
Algorithm Predictions/Outputs	Predicted Operative	TP	FP
	Predicted Conservative	FN	TN

Column entries for determining sensitivity
Column entries for determining specificity

Sensitivity = TP / (TP + FN)
Specificity = TN / (TN + FP)
Positive predicting value (PPV) = TP / (TP + FP)
Negative predicting value (NPV) = TN / (FN + TN)
Accuracy = (TP + TN) / (TP + FP + FN + TN)

Table 1. Model performance metrics when trained using all radiographs.

Sensitivity	85.71%
Specificity	93.85%
Positive Predictive Value	90.00%
Negative Predictive Value	91.04%
Accuracy	90.65%