## Utilizing Deep Learning to Classify Distal Radial Fractures to Improve Orthopaedic Referrals

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INTRODUCTION: Distal radial fractures (DRFs) are among the most frequently encountered orthopaedic injuries to primary care providers. There is a growing need for more efficient triage to quickly and reliably classify which distal radial fractures require orthopaedic intervention. Convolutional neural networks (CNNs) utilize deep learning to process and classify images. Using CNNs, the purpose of this study is to create a reliable model that can be used in a primary care setting for orthopaedic referrals which provides consistent and objective assessment of DRF operative status.

METHODS: A total of 148 DRFs were included from a single Level I trauma center in a major metropolitan center. Inclusion criteria included all patients 18 to 65 years old. Exclusion criteria included no prior surgeries. Screenshots of the radiographs were used for model training. Only lateral views were included. The dataset was split 80:20 (training:validation sets). Several pre-trained CNNs were tested in python via TensorFlow and Keras, including a Basic CNN, VGG16, ResNet18, ResNet50, MobileNet, DenseNet, EfficientNet, and InceptionNet with 1 or 3 top trainable layers. Parameters for model evaluation included: accuracy, sensitivity, positive predictive value (PPV), and F1 score.

RESULTS: The range of accuracies and F1 scores for the 8 models tested were 43% to 80% and 17% to 79%. Of these, the best performance yielded 80% accuracy, 82% PPV, 69% sensitivity, and 75% F1 score, (and sensitivity, PPV, F1 score) which was from the MobileNet. A close second was the DenseNet with 80% accuracy, 89% PPV, 62% sensitivity, and 79% F1 score. Heatmaps were generated to assess how the models were classifying images. The majority of images were correctly classified focused on the distal radius fracture itself, validating that the model was identifying the area of interest on the radiograph and classifying properly.

DISCUSSION AND CONCLUSION: The present study demonstrated the ability of CNNs to accurately classify the operative status of lateral DRF radiographs. Future work will focus on improving accuracy by including additional views and demographics as well as a larger dataset. This work shows promise for use in a primary care setting. Overall, the use of this model by referring providers to quickly and accurately assess the operative status of fractures could reduce



| for           |          |           |        | orthopaedic |                     |                         |                     |                     |
|---------------|----------|-----------|--------|-------------|---------------------|-------------------------|---------------------|---------------------|
| Model         | Accuracy | Precision | Recall | F1<br>Score | Total<br>Parameters | Trainable<br>Parameters | Number of<br>Epochs | Trainable<br>layers |
| CNN Basic     | 0.433    | 0.433     | 1.000  | 0.605       | 25710145            | 25709953                | 80                  | All                 |
| VGG16         | 0.460    | 0.435     | 0.838  | 0.572       | 14739777            | 4744705                 | 14                  | 3                   |
| ResNet18      | 0.607    | 0.543     | 0.592  | 0.565       | 9639809             | 1052673                 | 11                  | 3                   |
| ResNet50      | 0.727    | 0.738     | 0.585  | 0.645       | 25686913            | 2103297                 | 22                  | 3                   |
| MobileNet     | 0.800    | 0.818     | 0.692  | 0.750       | 4279489             | 2101249                 | 15                  | 3                   |
| Efficient Net | 0.567    | 0.000     | 0.000  | 0.000       | 5362340             | 1724929                 | 20                  | 3                   |
| DenseNet      | 0.800    | 0.889     | 0.615  | 0.794       | 8088129             | 1052673                 | 29                  | 3                   |
| InceptionNet  | 0.603    | 0.660     | 0.100  | 0.167       | 23901985            | 2099201                 | 21                  | 3                   |

surgeons.