## Using a convoluted neural network to determine bone mineral density from plain film x-rays

Brandon G Hill<sup>1</sup>, Frances Koback, Wayne E Moschetti<sup>2</sup>, Peter Schilling <sup>1</sup>Orthopaedics, Dartmouth-Hitchcock Medical Center, <sup>2</sup>Dartmouth Hitchcock Medical Center INTRODUCTION:

Cementless total knee arthroplasty (TKA) is ideal for patients with dense, high-quality bone due to its better initial stability and long-term osseointegration. Surgeons commonly assess bone density during surgery using visual and tactile feedback to choose between cemented or cementless fixation. This study evaluates a convolutional neural network's (CNN) ability to quantify the density of bone in the proximal tibia from preoperative radiographs which could aid in patient selection for cementless TKA.

METHODS: A dataset comprising 1,644 knee X-ray images across 587 patients and the corresponding lateral and medial tibial plateau bone mineral density (BMD) scores was utilized. These patients came from five different clinical sites, were between the age of 50-80 and were identified as having or being at risk for knee osteoarthritis (OA). BMD scores were obtained from dual-energy X-ray absorptiometry (DEXA). The X-ray images were preprocessed to ensure consistency and quality. A convolutional neural network (CNN) architecture was designed and trained to map the raw knee X-ray images to BMD scores. The dataset was divided into training, validation, and test sets (70/15/15%) ) to evaluate the model's performance. Key metrics such as mean absolute error (MAE), mean squared error (MSE), and correlation coefficient (r) were used to assess the accuracy of the predicted DEXA scores against the actual scores. RESULTS:

The CNN exhibited excellent predictive performance, with a high correlation coefficient (r = 0.72/0.65 medial/lateral) between the predicted and actual BMD scores. In predicting the medial/lateral scores, the MAE was 0.12/0.11, and the MSE was 0.02/0.02, indicating minimal deviation between the predicted and actual values.

DISCUSSION AND CONCLUSION:

The developed CNN model demonstrates strong potential in accurately predicting tibial BMD from plain knee X-ray images. This method provides an objective and quantifiable assessment of bone density, which can significantly aid in the decision-making process for TKA fixation methods. Additionally, this tool could facilitate the collection and analysis of BMD data which could have much broader applications.