Artificial Intelligence Can Accurately and Efficiently Measure Radiographic Parameters After Cephalomedullary Nail Fixation of Intertrochanteric Femur Fractures

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INTRODUCTION: The goal of this study was to develop and evaluate an artificial intelligence (AI) tool to automatically measure postoperative anteroposterior (AP) and lateral radiographs (XR) after cephalomedullary nail (CMN) fixation of intertrochanteric (IT) femur fractures. Measurements of interest included 1) endosteal diameter, 2) femoral shaft diameter, 3) tip-apex distance, 4) lag screw prominence, and 5) neck-shaft angle.

METHODS: Postoperative AP (303) and lateral (301) XRs of 368 patients who received short (170 cm or 180 cm) or intermediate (200-240 cm) length CMNs for IT femur fractures were retrieved. AP and lateral XRs were manually segmented and used to train two AI algorithms (Figure 1). Fifty-three pairs of AP and lateral XRs of a separate testing cohort of 27 patients were prepared and measured by three orthopedic surgeons and the trained AI algorithms. Both manual and AI-predicted measurements were corrected using the implants' known diameter and nail-screw angle. The endosteal diameter, femoral shaft diameter, and tip-apex distance were finalized as the mean value measured on the AP and lateral XR, while lag screw prominence and neck-shaft angle were only measured and hence finalized on the AP XR. Intraclass Correlation Coefficients (ICC) were calculated to assess inter-human and human-AI agreements on all measurements. Mean absolute errors (MAE) were used to assess AI errors with respect to mean human measurements.

RESULTS: The resulting metrics (ICCs and MAEs) are reported in the order of endosteal diameter, femoral shaft diameter, tip-apex distance, lag screw prominence, and neck-shaft angle. The ICCs for inter-human agreements were 0.80, 0.97, 0.91, 0.99, and 0.93, respectively. The ICCs for human-AI agreements were 0.84, 0.94, 0.83, 0.98, and 0.93, respectively. The MAEs (standard deviation) were 0.8 (0.7) mm, 0.8 (0.5) mm, 1.0 (0.6) mm, 1.1 (0.7) mm, and 3 (3) degrees, respectively. It took the AI algorithms 6 seconds on average to measure each radiograph.

DISCUSSION AND CONCLUSION: A fast, accurate, and automated AI tool was developed to measure postoperative XRs after CMN fixation of an ITF fracture. Going forward, endosteal and femoral shaft diameter measurements can be used to determine how the interplay of cortical thickness, canal diameter, and nail diameter impact clinical outcomes across large series of patients. Lag screw prominence and neck shaft angle can additionally help quantify varus collapse and femoral neck subsidence. This AI tool can help quickly and accurately assess radiographic outcomes on a large scale, which will facilitate future research.

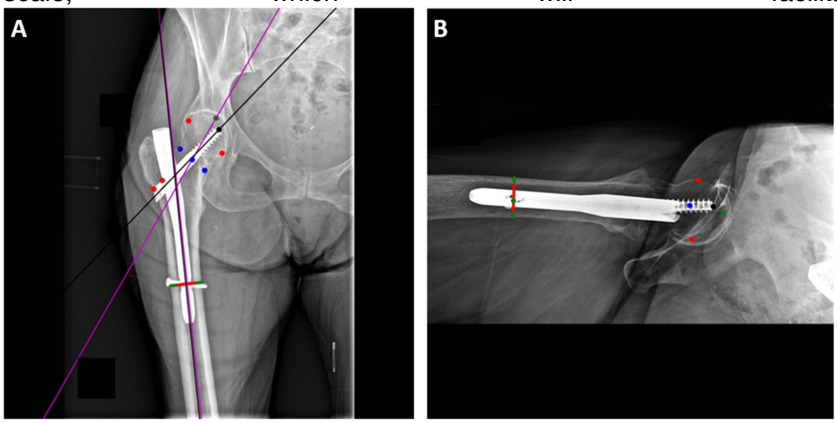

Figure 1. This figure illustrates how trained AI algorithms assess the AP (left) and lateral (right) postoperative radiographs and measure 1) endosteal diameter, 2) femoral shaft diameter, 3) tip-apex distance, 4) lag screw prominence, and 5) neck-shaft angle, by annotating the associated points and lines. All five measurements are performed on the AP radiograph, while only endosteal diameter, femoral shaft diameter, and tip-apex distance are measured on the lateral radiograph.