Validation of a 2D Artificial Intelligence Camera to Assess Hand, Wrist, and Forearm Range of Motion

Alexander D Jeffs, Andrew Allen, Stephen Mark Himmelberg, Bryan Crook, Zohair Zaidi, Marc Joseph Richard, Gaurav Aman Luther

INTRODUCTION:

Artificial intelligence (AI) is an emerging technology with potential applications for orthopaedic surgeons. Exer is a 2D AI-camera application that uses convolutional neural networks to assess range of motion (ROM). The aim of this study was to determine the validity of using a 2D AI-camera (Figure 1) as a tool for measuring hand, wrist, and forearm ROM. We hypothesized that a 2D AI-camera would have high inter-rater reliability and high positive correlation with traditional manual goniometer readings.

METHODS:

Fifty patients presenting to an outpatient hand clinic were prospectively recruited over a one-month period to appropriately power the study. All patients ages 18-75 years who presented to clinic with upper extremity pathology and no immobilization were eligible for inclusion. For each patient, 27 ROM measurements were performed beginning with manual goniometry by a fellowship-trained hand surgeon (MD), followed by manual goniometry by an athletic trainer (ATC), and then the 2D AI-camera app. The primary outcomes of interest were the inter-rater reliability (intraclass correlation coefficient (ICC)) and the correlation between raters (pearson correlation coefficient (PCC)). Measurement time was recorded. We reported ICC and PCC values as significant at an alpha error of less than 0.05.

RESULTS: The mean patient age was 49.2 years. The inter-rater reliability was statistically significant and excellent (ICC >0.9, $p<0.05$) for 96% of the measurements. Forearm pronation was the only ROM measurement that was not statistically significant, with the ICC rated as good (0.08, $p>0.05$). A comparison between the MD and the 2D AI-camera, as well as the ATC and the 2D AI-camera, demonstrated strong concurrent validity for 96.3% of measurements and moderate concurrent validity for 3.7% of measurements. All PCC values were statistically significant among the MD, ATC, and 2D AI-camera measurements ($p<0.05$). The mean time to completion of all measurements was nearly 4 min faster using the 2D AI-camera than the MD (60 sec vs 273 sec, $p<0.05$).

DISCUSSION AND CONCLUSION:

The 2D AI-camera demonstrated good-to-excellent inter-rater reliability and strong-to-moderate concurrent validity for all tested motions in the upper extremity. The 2D AI-camera exhibited a significant reduction in the time to obtain motion measurements compared to the MD ($p<0.05$).

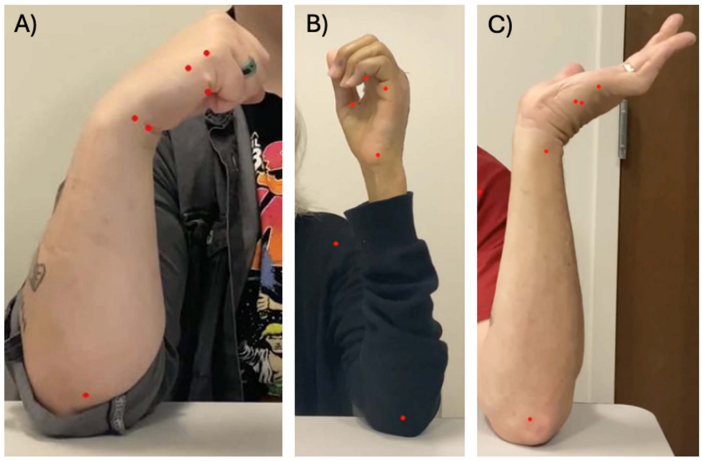

Figure 1. Example images from the 2D AI-Camera. A) Wrist flexion, B) SF MCP-PIP-DIP Flexion, and C) Wrist Extension