AI Autonomously Measures Cup Orientation and Identifies Retroversion from Four Million Radiographs

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INTRODUCTION:
Artificial intelligence (AI) algorithms were recently shown to outperform hand measurements in determining cup orientation from a single anteroposterior (AP) pelvis radiograph. Meanwhile, data augmentation has shown to improve model adaptability when applied to a novel patient series. This study designed an AI program to autonomously determine cup orientation, correct for pelvis orientation, and identified cup retroversion from a single anteroposterior (AP) pelvis radiograph and compare its accuracy to hand and CT measurements.
METHODS:
2,945 patients between 2012 and 2019 were identified to have 504 CT scans of their THA. 3D reconstruction was performed on all CT scans with Materialise Mimics, where cup orientation was measured in reference to the anterior pelvic plane. 5,201 corresponding AP pelvis radiographs were randomly allocated to 4,000 for training, 511 for validation, and 690 for testing. Data augmentation was applied to the training set (n=4,000,000) to increase model robustness. Test group was compared to cup measurements in accordance with methods described by Lewinnek et al.
RESULTS:
The AI predictions averaged 0.22 $\pm$ 0.03 seconds to run on a given radiograph. AI measurements showed a Pearson correlation coefficient of 0.96 with CT measurements, while hand measurements had 0.67. AI measurements more closely represented CT measurements when compared to hand measurements ($p<.001$). Hand measurements averaged $1.67° \pm 8.05°$ ($p=.002$) less than CT measurements, while AI averaged $0.19° \pm 2.92°$ ($p=.675$) above CT measurements. The AI algorithm identified 17 radiographs as having retroverted cups with 100.0% accuracy (total retroverted, n=45).
DISCUSSION AND CONCLUSION:
AI algorithms may correct for pelvis orientation when measuring cup orientation on radiographs, outperform hand measurements, and may be implemented in a timely fashion. This is the first method to identify a retroverted cup from a single AP radiograph.