Artificial Intelligence to Automatically Measure Lateralization and Distalization of the Glenosphere and Humerus After Primary Reverse Shoulder Arthroplasty

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INTRODUCTION: Distalization and lateralization are important parameters to consider after implantation of a primary reverse shoulder arthroplasty (RSA). However, the effects of distalization and lateralization on the outcomes and complications of RSA have remained elusive: studying them would require measuring these parameters on a very large number of shoulders, which is extremely tedious and time-consuming when attempted manually. Leverage of artificial intelligence (AI) tools may prove beneficial to answer these questions. A previous work has developed an AI algorithm to automatically segment radiographs obtained after RSA and identify the glenoid component, humeral component, supraspinatus fossa line, acromion (A), greater tuberosity (GT), pivot point (PP), and other regions of interest, and use those identified markers to measure the glenoid inclination, humeral component varus-valgus orientation, and the overall lateralization and distalization shoulder angles (LSA & DSA). The goal of this work was to develop an AI algorithm that divides the LSA and DSA in angular components reflecting the relative contributions of the glenoid and humerus, as well as the position of the PP and GT as measured in reference to the acromion in millimeters.

METHODS: The postoperative radiographs of 86 shoulders that had undergone a primary RSA were used as testing data. Three human observers manually and independently measured the following: glenoid lateralization angle (**GLA**, between superior glenoid, A and PP), humeral lateralization angle (**HLA**, PP – A – GT), glenoid distalization angle (**GDA**, A – superior glenoid – PP), humeral distalization angle (**HDA** A – superior glenoid – GT), and horizontal and vertical distances between A and PP and A and GT (**A-PPh, A-PPv, A-GTh, A-GTv**) corrected to the known diameter of the glenosphere. A in-house AI segmentation algorithm (U-net) was used to segment all testing radiographs. An automated image-processing pipeline was developed to use the automatically segmented areas to perform the same measurements described above. Intraclass Correlation Coefficients (ICC) were calculated to compare measurements performed manually by all three observers, as well as to compare the average observer measurements with the AI measurements. Mean absolute error (MAE) was used to assess the error of AI measurements with respect to average observer measurements.

RESULTS: Resulting metrics (ICC and MAE) are reported in the order of A-PP-h, A-PP-v, A-GT-h, A-GT-v GLA, HLA, GDA, and HDA, respectively. The corresponding ICCs amongst human observers were 0.84, 0.94, 0.81, 0.79, 0.81, 0.93, 0.88, and 0.88. The ICCs between AI measurements and the averages of manual measurements were 0.91, 0.96, 0.95, 0.94, 0.73, 0.94, 0.87, and 0.78. The MAEs of the AI algorithm were 1.6 mm, 1.0 mm, 1.3 mm, 2.6 mm, 3 degrees, 3 degrees, 2 degrees, and 1 degree. The AI algorithm and pipeline automatically segmented and measured all testing radiographs (n=86) within 80 seconds.

DISCUSSION AND CONCLUSION: The AI algorithm developed in this study could automatically measure the lateralization and distalization of the glenoid and humeral components in both distances and angles on postoperative radiographs obtained after RSA within 1-2.6 mm and 1-3 degrees of average manual measurements. Agreements between AI measures and human observers were good to excellent and were associated with low errors. This AI algorithm and pipeline add to the armamentarium of tools available to automatically and efficiently assess radiographic outcomes after RSA.

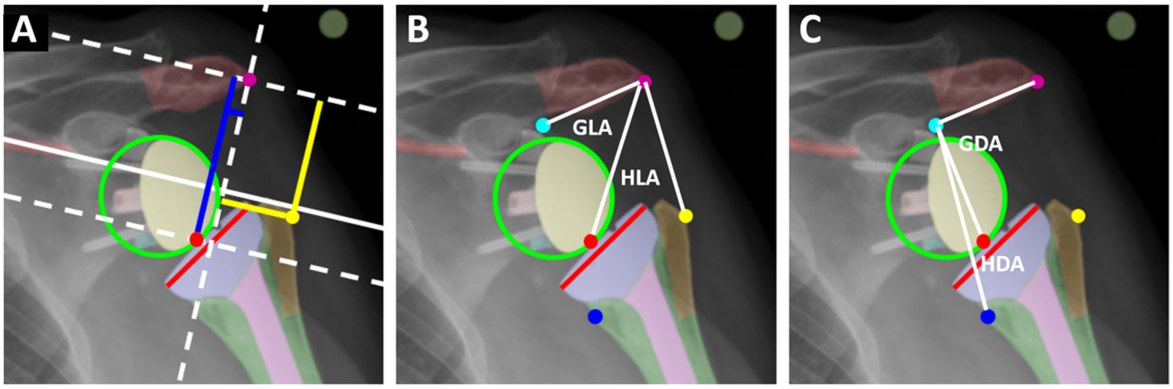

Figure 1. The scapular floor line (fossa line, white line) is used as the lateral direction. A) Pivot point (PP, red point) and greater tuberosity (GT, yellow point) were used to calculate A-PPh and A-PPv (blue lines parallel and vertical to fossa line) and A-GTh and A-GTv (yellow lines parallel and vertical to fossa line). B) illustration of glenoid lateralization angle (GLA) and humeral lateralization angle (HLA). C) illustration of glenoid distalization angle (GDA) and humeral distalization angle (HDA).