Does the Best-Fit-Circle Technique Really Replicate Pre-arthritic Anatomy? A Study of Reliability and Correlation

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Background: Application of a best-fit circle (BFC) to preserved non-articular humeral landmarks is a method for 2-dimensional assessment of anatomic humeral replication in the coronal plane for glenohumeral osteoarthritis. The technique has been applied both preoperatively and postoperatively to gauge appropriateness of prosthetic humeral head size and positioning for anatomic shoulder replacement. To date, there are no studies to support the BFC technique results by comparing ipsilateral, pre-pathologic humeral head anatomy to the results of the BFC technique. We hypothesized that our study would corroborate the BFC technique.

Materials and methods: Three-dimensional CT scan images of 76 proximal humeri without evidence of humeral head deformity were rotated to mimic a Grashey radiographic view and then printed on paper using a 1:1 scale. Three surgeons with varying clinical experience marked and measured the radius of curvature (ROC), humeral head height (HHH), and center of rotation position (COR) to the nearest 1mm. Intraclass correlation coefficients (ICCs) were calculated to demonstrate correlation strengths between intra- and interobserver measurements. Results obtained by direct measurement of the specimens and those from the BFC technique were tested for correlation using the Pearson correlation coefficient (PCC). A difference of measurement between results of the two techniques of ≥ 4mm was considered clinically significant.

Results: The reliability for ROC measurements made between different observers was excellent both when directly measuring ROC (ICC = 0.93; 95% confidence interval (CI): 0.88-0.96; $p < 0.001$) and when using the BFC technique (ICC = 0.92; 95% CI: 0.8-0.96; $p < 0.001$). The average difference between ROC obtained by direct measurement versus BFC technique was 0.1mm. The maximum ROC difference between techniques never reached clinical significance (maximum difference was ≤ 1.7mm). Results for comparing ROC by direct measurement versus the BFC technique were highly correlated (PCC = 0.97; $p < 0.001$). The reliability for HHH measurements made between different observers was poor both when directly measuring HHH (ICC = 0.4; 95% CI: 0.15-0.6; $p < 0.001$) and when using the BFC technique (ICC = 0.42; 95% CI: 0.27-0.56; $p < 0.001$). The maximum HHH difference when comparing HHH obtained by direct measurement versus BFC technique was not considered clinically significant in any cases (average difference = 0.3mm; maximum difference = 3mm in 2/76 cases). Results for comparing HHH by direct measurement versus BFC technique were moderately correlated (PCC = 0.72; $p < 0.001$). Differences in COR position between techniques were not clinically significant, but the reliability between observers for this measurement was low (ICC = 0.24; 95% CI: 0.1-0.38; $p < 0.001$).

Discussion: Results of the BFC technique are highly reliable and correlate well with the native, pre-arthritic anatomy when measuring humeral head ROC, but are less so when measuring HHH. Reliability between observers when measuring changes in COR between techniques was low, raising the question of whether or not the BFC technique reproducible enough for studying pre- and postoperative changes in COR. Surgeons should consider these results when interpreting studies that utilize the BFC technique.

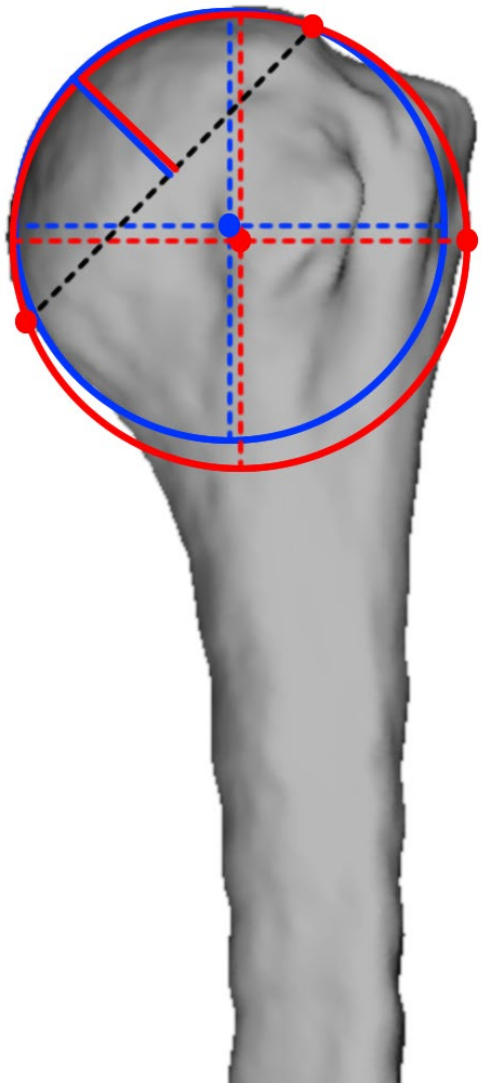

Figure: An example comparing the best-fit circle (BFC) technique (red) to direct measurement (blue) on this non-arthritic proximal humerus specimen. Use of the BFC technique results in slightly different values for radius of curvature, humeral head height, and center of rotation compared to direct measurement.