Significant Variability Exists in Preoperative Planning Software Measures of Glenoid Morphology for Shoulder Arthroplasty

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Introduction

- Total shoulder arthroplasty (TSA) and reverse TSA (RTSA) are mainstays of definitive management of degenerative and acute shoulder conditions

- However, both are subject to relatively high failure rates compared to hip and knee arthroplasty[1,2]

- Excess superior tilt increases rotator cuff dysfunction for TSA[3], excess retroversion is associated with osteolysis[4] and loosening and outcomes are worse for RTSA patients with component malposition[5]

- 3D imaging has become increasingly relied upon for preoperative planning[6] and current literature demonstrates improved component positioning with its use with preoperative planning[7]

- Denard et al[8] recently showed high variability between VIP and Blueprint for glenoid version and inclination measurements, but there have been no studies including comparisons among these and TrueSight and Exactech GPS or human measurement

- VIP, TrueSight and ExactechGPS are landmark-based and measurements are done after manual idenftification of these landmarks by a company representative while Blueprint is automated and cases can be planned without a company technician and with scapular truncation

- Additionally, it is unclear how glenoid deformity affects measurement

- We sought to assess interrater reliability among 4 preoperative planning platforms and a MSK radiologist's measurements of glenoid version and inclination and to determine if increased glenoid deformity increases variability of measurements

- We hypothesized that there would be significant variability among preoperative planning platforms and MSK radiology and that greater deformity would result in increased variability

Methods

- *A priori* power analysis determined 76 subjects would provide 80% power to detect test-retest correlation of at least 0.4
- 76 shoulder CT scans of patients undergoing TSA or RTSA were retrospectively obtained
- DICOMs uploaded to VIP (Arthrex), Blueprint (Wright Medical), TrueSight (Stryker/Materialise) and Exactech GPS (Exactech) platforms
- Manual measurements performed by board-certified fellowship-trained MSK radiologist
- Axial CTs reformatted into scapular anatomic plane using 3D imaging software (Horos)
- Manual glenoid version measurement obtained using Friedman's line[9]
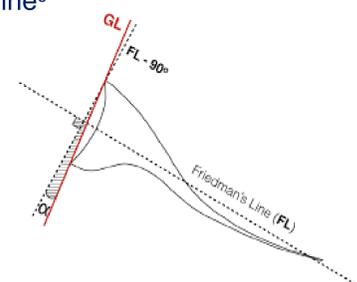
- Manual glenoid inclination measurement was obtained in the scapular plane measuring angle β, the angle between the floor of the supraspinatus and the glenoid fossa[10]
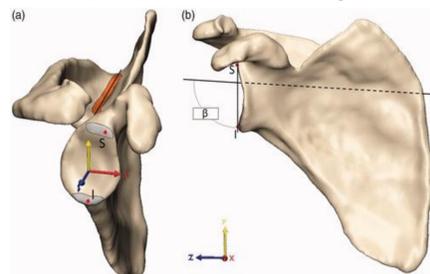
- All studies with glenohumeral osteoarthritis were classified by the non-modified Walch classification[11]
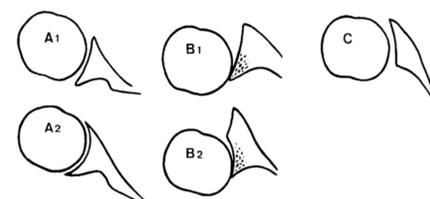

- 2-way mixed intra-class correlation coefficients (ICC) calculated for inclination and version as measured by 4 platforms to determine inter-rater reliability
- ICC also calculated for subgroups of Walch classification
- Welch's t-test employed to compare Walch A and B, 1-way ANOVA employed to compare ICC among Walch A1, A2, B1 and B2
- Lin's concordance correlation coefficient (CCC) using a Fisher Z-transformation was calculated for each templating software against MSK radiology
- Significance was determined using 1-way ANOVA
- Tukey HSD pairwise comparisons were made for significant ANOVA findings

Results

- 76 shoulders (51 TSA, 25 RTSA) with 59 undergoing surgery for OA, 17 for cuff tear arthropathy; zero CTs with medial or inferior truncation of the scapula
- 40 shoulders were Walch A (12 A1, 28 A2), 18 Walch B (8 B1, 10 B2) and 1 Walch C
- Average overall version
  - MSK Radiology: -5.99°
  - VIP: -8.29°
  - Blueprint: -10.88°
  - TrueSight: -9.83°
  - ExactechGPS: -10.14°
- Average overall inclination
  - MSK Radiology: 8.89°
  - VIP: 9.45°
  - Blueprint: 9.32°
 - TrueSight: 5.95°
  - ExactechGPS: 1.09°

Version

- Overall ICC of the 4 platforms' version was 0.905 indicating **good to excellent inter-rater reliability**
- **VIP's version had the highest concordance** with MSK radiology (0.828) and **Blueprint had the lowest** (0.743)
- Walch A glenoids showed greater inter-rater reliability (0.881) than Walch B (0.733) (p=0.0320)
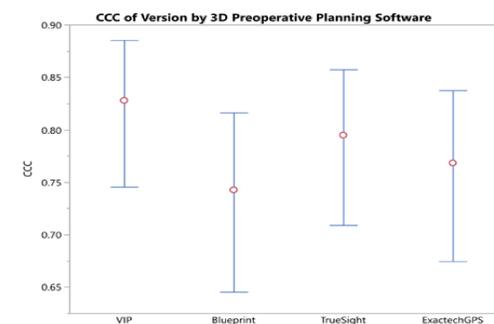
Inclination

- Overall ICC of the 4 platforms' inclination was 0.748, indicating **moderate to good reliability**
- **Blueprint's inclination had the highest concordance** with MSK radiology (0.679) and **ExactechGPS had the lowest** (0.387)
- Walch A glenoids showed greater inter-rater reliability (0.768; CI 0.659-0.857) than Walch B (0.549; CI 0.317-0.766) (p=0.024)
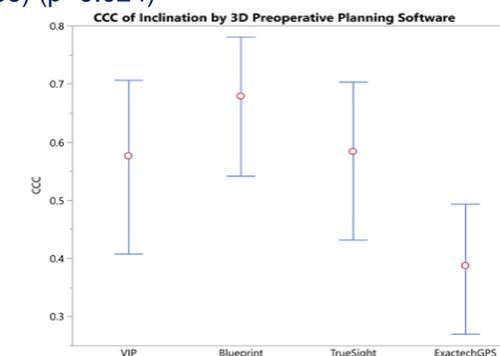
Discussion

- The overall **inter-rater reliability of the platforms was good to excellent for version** but only **moderate to good for inclination**
- Inter-rater **reliability was significantly lower for Walch B glenoids**
- For version, **VIP had the highest concordance** with MSK radiology and **Blueprint had the lowest**
- For inclination, **Blueprint had the highest concordance** with MSK radiology and **ExactechGPS had the lowest**

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