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Surgeon vs. semi-automated software measured assessment of glenoid retroversion

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Abstract

Preoperative anatomic measurements in total shoulder arthroplasty (TSA) influence a surgeon's decision-making process in deciding treatment options for a given patient. Glenoid retroversion is one of the most significant measurements and can be highly subject to intra- and inter-observer variability in measurement technique. This study compares surgeon measured retroversion values to semi-automated software measured retroversion values on the same 1862 computed tomography scans, showing consistent measurements with an average absolute mean error between the two techniques of 3.1 ± 3.6°.

1 Introduction

Glenoid retroversion is one of the main anatomic parameters to which scapular and glenohumeral joint morphology are measured. This measurement is one of many important radiographic data points in determining treatment options for a shoulder patient in both sports and total shoulder arthroplasty (TSA) procedures.

The most prevalent retroversion measurement technique reported in the literature is the Friedman Axis method, which calculates the angle between two lines on an axial computed tomography (CT) image that bisects the middle of the glenoid. The Friedman Axis is created by drawing a line between the most medial point on the trigonum of the scapula to a second point on the glenoid center. The resulting retroversion angle is then measured between this axis and a second line drawn from the most anterior point to the most posterior point on the glenoid face[1].

Research has shown that this measurement has significant implications on surgeon thought process influencing potential treatment for a given patient. For TSA specifically, many surgeons may be more likely to choose an augmented glenoid component or default to reverse total shoulder arthroplasty when faced with significant glenoid retroversion[2,3]. However, the validity of this measurement is subjective to both inter- and intra-observer variability, as well variability that presents when measuring in two-dimensions (2D) vs. three-dimensions (3D)[4].

As 3D preoperative planning software has become the gold standard in TSA, many authors have highlighted the variability in retroversion measurements when the same CT scan is measured by different programs, highlighting the importance of standardizing such important anatomic measurements[5]. The purpose of this study is to compare the differences between surgeon measured retroversion angles compared to automated measurements presented by a 3D preoperative planning software.

2 Material and methods

2.1 Data collection

Glenoid retroversion angles were measured via the Friedman method on 1862 CT scans from TSA patients enrolled in a global multi-center single implant registry. Each CT scan was then loaded into a 3D preoperative planning software (Equinoxe Planning App, Exactech, Gainesville, FL) which employed a semi-automated bone segmentation and Friedman Axis point placement process utilizing machine learning techniques supervised by trained technicians. Automated retroversion measurements were then calculated by the software and collected for each patient for direct comparison between surgeon and software measurements. Mean error, mean absolute error, standard deviations, and histogram categories were calculated in Microsoft Excel (Redmond, WA).

3 Results

3.1 Measurement Comparisons

Average retroversion measurements and standard deviations for each measurement technique as well as mean error and mean absolute error are displayed below in Figure 2. The mean error in measurement by the software compared to surgeon measurement was -1.3 ± 4.5°, meaning the software tended to measure each case with more retroversion, on average. Mean absolute error between the software and surgeon measurements was 3.1 ± 3.6°.

	Surgeon Measured Retroversion (°)	Software Measured Retroversion (°)	Mean Error (°)	Mean Absolute Error (°)
AVG	9.8	11.1	-1.3	3.1
STDEV	8.7	8.9	4.5	3.6

Figure 1: Average and standard deviations for surgeon and software measured retroversion on 1862 CT scans, along with mean and mean absolute errors between the two groups

Histogram values from surgeon measured retroversion angles vs. software measured retroversion angles are displayed below in Figure 2, with more retroverted values reported as negative values and more anteverted values reported as positive. 667 cases (35.8%) of cases were within ± 1° of error, 1179 cases (63.3%) of cases were within ± 3° of error, and 1470 cases (78.9%) were within ± 5° of error between the two measurement modalities.

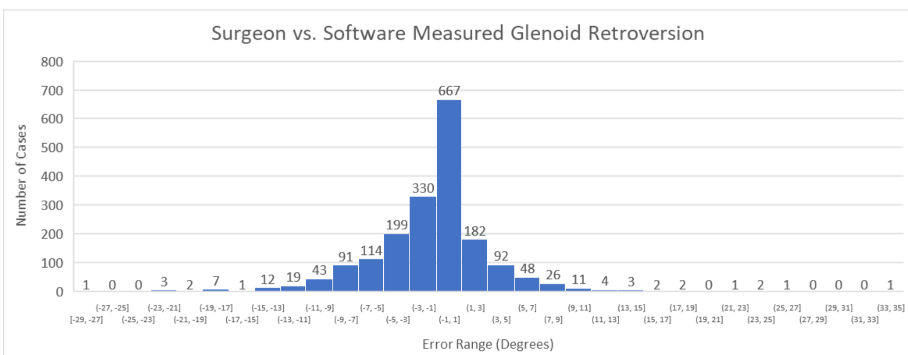

Figure 2: Surgeon measured retroversion angles vs. software measured retroversion angles on 1862 CT scans

4 Discussion

Good agreeability was shown between surgeon and software measured glenoid retroversion values in this study, with nearly 4 in 5 cases falling within 5 degrees of error between surgeon and software measurement techniques. Given the multitude of preoperative planning software platforms that are commercially available, this data helps support the presentation of retroversion values from a common and consistent platform.

This study also highlights the potential for preoperative planning software to standardize more anatomic measurements (many of which have reported disputed techniques) in TSA, including subluxation and inclination which also reference the Friedman Axis[6]. Computer automated measurements provide the advantage to help reduce variability between users and allow a more direct patient comparison from surgeon to surgeon.

Limitations of this study include multiple surgeon observers in the surgeon-measured cohort, which introduces variability in the measurement technique between cases.

Future work includes sub analyses of this dataset to examine the impact of Walch glenoid classification on measurement agreement, as well as if severe glenoid wear and extreme retroversion impact differences between the two measurement techniques[7]. Further validation of additional automated software measured anatomic measurements in TSA will continue to be investigated.

5 Significance/Clinical Relevance

This study reports good agreeability between surgeon and semi-automated software reported glenoid retroversion measurements, which has the potential to lead to more consistent reported measurement techniques in the future.

References

1. Friedman, R. J., Hawthorne, K. B. & Genez, B. M. The use of computerized tomography in the measurement of glenoid version. *J Bone Joint Surg Am* **74**, 1032–1037 (1992).
2. Parsons, M. *et al.* Assessment of surgeon variability in preoperative planning of reverse total shoulder arthroplasty: a quantitative comparison of 49 cases planned by 9 surgeons. *Journal of Shoulder and Elbow Surgery* S1058274620302342 (2020) doi:10.1016/j.jse.2020.02.023.
3. Parsons, M. *et al.* Intersurgeon and intrasurgeon variability in preoperative planning of anatomic total shoulder arthroplasty: a quantitative comparison of 49 cases planned by 9 surgeons. *Journal of Shoulder and Elbow Surgery* S1058274620303074 (2020) doi:10.1016/j.jse.2020.04.010.
4. Reid, J. J., Kunkle, B. F., Greene, A. T., Eichinger, J. K. & Friedman, R. J. Variability and reliability of 2-dimensional vs. 3-dimensional glenoid version measurements with 3-dimensional preoperative planning software. *Journal of Shoulder and Elbow Surgery* **31**, 302–309 (2022).
5. Erickson, B. J. *et al.* Does commercially available shoulder arthroplasty preoperative planning software agree with surgeon measurements of version, inclination, and subluxation? *Journal of Shoulder and Elbow Surgery* **30**, 413–420 (2021).
6. Shukla, D. R., McLaughlin, R. J., Lee, J., Nguyen, N. T. V. & Sanchez-Sotelo, J. Automated three-dimensional measurements of version, inclination, and subluxation. *Shoulder Elbow* **12**, 31–37 (2020).
7. Vo, K. V., Hackett, D. J., Gee, A. O. & Hsu, J. E. Classifications in Brief: Walch Classification of Primary Glenohumeral Osteoarthritis. *Clin Orthop Relat Res* **475**, 2335–2340 (2017).