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Factors predicting postoperative range of motion for anatomic total shoulder arthroplasty

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Background: Total shoulder arthroplasty (TSA) has repeatedly been shown to be an effective and durable treatment option for end-stage arthritis with good long-term survivorship. Whereas pain relief is typically the primary goal, improvements in range of motion are typically expected as well. The factors that influence postoperative motion have not been well characterized. The purpose of the study was to examine the factors that influence ultimate postoperative motion after TSA.

Methods: A retrospective review was conducted of prospectively collected data of 230 patients with minimum 1-year follow-up after TSA for end-stage arthropathy with an intact rotator cuff. Analysis was focused on factors that may correlate with postoperative measured forward flexion, abduction, external rotation, and internal rotation. Included in this analysis was perception of motion, age, body mass index (BMI), comorbidities (smoking, diabetes, osteoporosis, hypercholesterolemia, inflammatory arthritis, and thyroid disease), and number of comorbidities.

Results: Preoperative motion in all directions was predictive of postoperative motion for forward flexion ($R = 0.235$; $P < .001$), abduction ($R = 0.363$; $P < .001$), external rotation ($R = 0.325$; $P < .001$), and internal rotation ($R = 0.213$; $P = .002$). BMI and diabetes both negatively correlated with internal rotation ($R = -0.134$, $P = .40$ and $R = -0.196$, $P = .003$, respectively). Individual and total number of comorbidities were not predictive of postoperative motion. The patient's perception of preoperative motion also did not correlate with postoperative motion.

Conclusions: Preoperative range of motion before TSA is most predictive of final motion achieved. Individual and total number of comorbidities are not predictive of postoperative motion. Patients with high diabetes and increased BMI have limited postoperative internal rotation.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Total shoulder arthroplasty; TSA; range of motion; comorbidities

Anatomic total shoulder arthroplasty (TSA) is widely accepted as a reliable treatment option for patients suffering from end-stage glenohumeral arthritis.[6,19] Through multiple studies, TSA has been shown to be effective[10] and durable,[10] with good long-term survivorship of the operation.[4,24] Whereas pain relief is typically the primary goal of patients who elect to undergo this procedure, improvements in range of motion (ROM) are usually expected as well.[12]

An exemption from Institutional Review Board review was obtained as this study met the conditions for exemption under 45 CFR 46.101(b) (4). A Request for Waiver of Authorization for Use and Disclosure of Protected Health Information (PHI) was obtained. No informed consent was necessary.

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Numerous studies have shown that TSA improves shoulder motion,[5,10,12,13,20] but the factors that predict postoperative motion in TSA are not well understood. In total knee arthroplasty, it is well established that preoperative ROM is the strongest predictor of postoperative ROM.[1,2,21] Other factors, such as intraoperative motion,[1,21] soft tissue releases,[1,21] gender,[11] and obesity,[18] have been shown to influence postoperative motion achieved after total knee arthroplasty. Unfortunately, there is a paucity of data regarding the factors that influence postoperative motion in shoulder arthroplasty. Analyzing patients undergoing reverse shoulder arthroplasty, Schwartz et al[23] determined that intraoperative forward flexion is the greatest predictor of postoperative ROM. Other studies have isolated factors that influence overall outcomes, such as better preoperative shoulder function,[7] limited preoperative external rotation,[13] and certain comorbidities.[22] However, no study to date has specifically analyzed the factors that influence ultimate postoperative motion after TSA.

It is imperative to educate patients on realistic expectations and outcomes after TSA to help achieve better overall patient satisfaction with the procedure. With this in mind, gaining a better understanding of which factors truly influence postoperative motion after TSA is vital in defining realistic patient expectations and ultimately producing satisfactory patient outcomes. The purpose of the study was to examine the factors that influence ultimate postoperative motion after TSA. We hypothesized that preoperative ROM would be the greatest predictor of postoperative ROM.

Materials and methods

A retrospective query of prospective collected data of all patients treated with TSA was conducted by the Holy Cross Shoulder Outcomes Repository. It has previously been established that postoperative motion plateaus at 12 months after TSA.[15] Thus, all patients who underwent TSA with an intact rotator cuff and a minimum follow-up of 12 months were included in this analysis. Patients with complications requiring revision surgery were excluded from this analysis.

A single shoulder fellowship-trained surgeon performed each TSA during a 7-year period (November 2006–November 2013). The surgical technique was identical for all patients with the exception of management of the subscapularis tendon. Patients were treated with a subscapularis peel if preoperative external rotation was $<0^\circ$ or there were signs of poor bone quality (i.e., history of osteoporosis or osteopenia). The remaining patients were treated with a lesser tuberosity osteotomy. All patients were treated with a TSA system that uses a cemented polyethylene glenoid and a modular humeral head (Encore Foundation or DJO Turon, Austin, TX, USA). Postoperative rehabilitation was standardized for all patients. Patients were placed in a shoulder immobilizer for the initial 6-week period and encouraged to initiate pendulum exercises 3 times daily. At 6 weeks, patients were instructed in self-directed supine active assisted exercises and were encouraged to use the extremity for light activities of daily living with a 2-pound weight restriction. After 3 months, patients were encouraged to continue self-directed stretching and strengthening exercises and were allowed to return to activities within comfort level.

ROM measurements including forward flexion, abduction, and external rotation were performed with a manual goniometer and entered into the repository as part of the standard protocol for all repository patients. Motion measurements were typically performed with the patient in a gown and were referenced on the basis of the angles formed between the arm and the torso. For forward elevation, the measurement was made from the side of the patient. For abduction, the measurement was made from behind the patient. External rotation measurements were made with the elbow pressed on the patient's torso with the arm at 0° of abduction. Internal rotation motion was based on the highest midline segment of the back that can be reached. Perceived motion was assessed using the repository by allowing each patient to select the picture that best represented his or her ability to achieve different directions of shoulder motion (forward flexion, abduction, and internal rotation). Each picture was correlated with its degree of motion (Fig. 1).

Data analyzed from the repository included measured preoperative and most recent postoperative motion, perceived preoperative and most recent postoperative motion, age at the time of surgery, body mass index (BMI), individual comorbidities (smoking, diabetes, osteoporosis, hypercholesterolemia, inflammatory arthritis, and thyroid disease), and total number of comorbidities. The focus of the data analysis was on the correlations of each variable with measured postoperative motion in each direction.

To determine the relationship between the variables analyzed in this study and postoperative ROM, linear regression analyses, Pearson correlations, Spearman correlations, and point-biserial correlations were used where appropriate. Correlation coefficients (R) and P values were reported to determine level of significance. Statistical analyses were performed with SPSS version 21 (SPSS Inc., Chicago, IL, USA), with significance set at $P < .05$.

Results

A total of 238 patients met the inclusion criteria for this study. The average age of subjects was 70 years (range, 45-89 years), with an average follow-up of 28 months (range, 12-82 months). There were a total of 121 men and 117 women. BMI averaged 29 (range, 18-49). Eight of the 238 subjects were removed from the final analysis because of postoperative complications: 1 patient with posterior subluxation, 4 patients with subscapularis insufficiency, 1 patient with a postoperative infection, 1 patient with postoperative neuropathy, and 1 patient with a postoperative rotator cuff tear. The remaining 230 patients were included in the final analysis.

Significant improvements in measured ROM were observed for all directions of motion (Table I). As seen in Table II and Figure 2, preoperative motion was predictive of measured postoperative motion. This was true for forward flexion ($R = 0.235$; $P < .001$), abduction ($R = 0.363$;