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Factors that predict postoperative motion in patients treated with reverse shoulder arthroplasty

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Background: Reverse shoulder arthroplasty (RSA) has proven to be a useful yet inconsistent tool to manage a variety of pathologic conditions. Factors believed to lead to poor postoperative range of motion (ROM) may be associated with preoperative diagnosis, poor preoperative ROM, and surgical factors such as inability to lengthen the arm. The purpose of this study was to analyze multiple factors that may be predictive of motion after RSA. Our hypothesis is that intraoperative ROM is most predictive of postoperative ROM.

Methods: Between February 2003 and April 2011, 540 patients (217 men and 323 women) treated with RSA were evaluated with measurements of preoperative, intraoperative, and postoperative ROM at a follow-up, where ROM was found to have plateaued at 1 year as determined by a pilot study. A regression analysis was performed to define independent predictive factors of postoperative active ROM.

Results: Intraoperative forward flexion was the strongest predictor of final postoperative ROM, followed by gender and preoperative ROM. Age and arm lengthening were not significant independent predictors. Controlling for gender and preoperative ROM, patients with an intraoperative elevation of 90° gained 29° in postoperative forward elevation ($P < .001$), 120° gained approximately 40° in postoperative forward elevation ($P < .001$), 150° gained approximately 56° in postoperative forward elevation ($P < .001$) and 180° gained approximately 62° in postoperative forward flexion ($P < .001$).

Conclusions: Intraoperative forward flexion is the strongest predictor of postoperative ROM. Surgeons may use intraoperative motion as a powerful decision-making tool regarding soft tissue tension in RSA.

Level of evidence: Level III, Retrospective Cohort Study, Treatment Study.

Keywords: Reverse shoulder arthroplasty; prognosis; preoperative motion; intraoperative motion; multivariable regression

Reverse shoulder arthroplasty (RSA) is a commonly used procedure for management of difficult shoulder problems such as massive and irreparable rotator cuff tears with and without glenohumeral arthritis, rotator cuff dysfunction secondary to proximal humeral fractures, and

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revision shoulder arthroplasty.[3,4,6-10,14,16,22,24,27,28] Overall, patients have improved restoration of function as a result. However, some inconsistency occurs in certain pathologies, such as patients with severe fatty infiltration of the teres minor,[21] previous arthroplasty,[26] management of certain fracture sequelae,[17] and even in patients with rotator cuff deficiency with or without glenohumeral arthritis. Poor outcomes still exist despite consistent technique applied by the surgeon.[2,6,7,15,18,27,28] These variable outcomes have been explained in various reports and are thought to be related to preoperative diagnosis,[6,27] patient gender,[19,25] preoperative motion,[5] and arm lengthening.[11,13]

A concept in total knee arthroplasty is that patients with poorer intraoperative motion are more likely to experience a reduction in postoperative motion. This implies that, despite the resolution of the mechanical failure and high friction of the articulation with arthroplasty, some influence of the soft tissues is responsible for the limits of patient function.[20] Similarly, the ability to achieve improvements in final motion in anatomic shoulder arthroplasty corresponds to the ability to correct soft tissue contracture, which can be evaluated intraoperatively.[1] In RSA, a great deal of controversy exists regarding the methods to ideally assess intraoperative soft tissue tension. The ideas that a joint should have a certain tightness—so-called decoaptation and coaptation[9]—or that the conjoint tendon should have a certain tension, are all subjective, with little to no objective support in the literature.

Furthermore, there are contrasting beliefs about what priorities should be accomplished during surgical reconstruction, with some authors striving for lengthening of the arm with the belief that deltoid tensioning may improve function.[11-13] Whether this can be justified is unclear, however, because the possible overtensioning may inherently lead to a reduction in intraoperative motion. Therefore, the goal of what tension or looseness of the novo joint should be accomplished at the time of surgery is unclear. To further understand which factors accurately predict outcome in RSA, we studied the importance of patient diagnosis, patient sex, preoperative range of motion (ROM), arm lengthening, and intraoperative ROM. We hypothesized that intraoperative ROM was the most predictive factor in outcome.

Methods

Inclusion criteria for the study were the presence of prospectively collected intraoperative forward flexion available in the patient's medical record between February 2003 and April 2011 and having undergone a RSA by the senior author (M.A.F.). A total of 802 patients met these criteria.

A pilot study was performed to determine the time point of postoperative rehabilitation where forward flexion plateaued after RSA. An analysis of patient-matched data of ROM from a random sampling of the 802 patients with 3, 6, 12, 24, and 36 months of follow-up data was performed with the purpose of evaluating what would be the minimal amount of time for the postoperative motion related to the surgery to plateau to ascribe the improvement in motion most related to the arthroplasty. The data were used to determine minimum and maximum follow-up time for recording of postoperative motion. If a difference between the pilot study comparisons was 5° or less, the patient's forward elevation was deemed to have plateaued. Therefore, ultimate use of that follow-up time period and data was allowed in our study. The analysis excluded patients who sustained a postoperative complication that would affect the postoperative motion; thus, 23 patients with postoperative complications such as acromial fracture (n = 14) or instability (n = 9) during the postoperative data collection period were excluded.

Ultimately, 540 of 802 patients with average follow-up of 19 months (range, 1-3 years) were retrospectively reviewed, of which 239 were excluded due to missing short-term or long-term follow-up. Among these excluded patients, 68 did not have preoperative follow-up, 56 had less than 3 months of follow-up, 46 had between 3 and 6 months of follow-up, and 69 had between 6 months and 1 year of follow-up. No patients were excluded due to preoperative diagnosis; the study included patients with rotator cuff deficiency without arthritis, cuff tear arthropathy, acute 3-part or 4-part proximal humeral fracture dislocations, proximal humeral fracture sequelae, infection, and revision arthroplasty.

ROM analysis

Preoperative and postoperative ROM assessment was performed using a digital goniometer on a videorecorded physical examination according to a previously published ROM protocol.[7] Patients were asked not to go beyond the point of pain or discomfort. Measurements were performed by an independent observer (B.J.C.) blinded to study design and purpose, and when unavailable, every patient completed a questionnaire that included self-assessed ROM indicated by marking the highest attainable motion on a picture that correlates with videorecorded measurements.[18,23] These measurements were taken from follow-up data that was closest to 2 years postoperative.

Intraoperative forward flexion (IFF) was determined by the senior surgeon (M.A.F.) after final implantation of the components and repair of the subscapularis in the operating room and was recorded in the operative report in 30° increments ranging between 0° and 180°. This was performed under a consistent combined regional and general anesthetic technique and patient positioning. At the time of measurement, the senior surgeon was blinded to study design. To compensate for potential observer bias, random samples from surgical videos of the patients in the study were measured for intraoperative ROM by the operating surgeon (M.A.F.) and an independent observer not involved in the surgical management of the patients. The operating surgeon had a high intraobserver correlation ($r = 0.717$). The independent observer measurements were also highly correlated with the operating surgeon ($r = 0.727$).

Radiographic analysis

Adequate preoperative and postoperative x-ray images were available for 457 of the 540 patients in the cohort. Those excluded had severe boney destruction of their proximal humerus or acromion, the preoperative x-ray film was deficient, or visualization of the greater tuberosity or deltoid tuberosity was unclear. Following a