# How Does Preoperative Shoulder External Rotation Stiffness Influence the Rate Of Motion Restoration After Anatomic Total Shoulder Arthroplasty?

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INTRODUCTION:

Anatomic total shoulder arthroplasty (aTSA) is a reliable operative to improve both pain and function in patients with primary osteoarthritis of the glenohumeral joint. Prior studies have shown it takes 2 years to achieve maximal benefits in overhead range of motion (ROM) following surgery. However, there remains a subset of patients who lag behind their peers in the rate at which they regain functional overhead motion. Preoperative stiffness may place patients at risk of disuse muscle atrophy, which may affect the rate at which they regain motion. The purpose of this study was to compare the rate of recovery in clinical outcomes of aTSA performed in stiff (preoperative passive external rotation [ER] ≤ 0°) versus non-stiff (preoperative passive ER > 0°) shoulders.

METHODS:

A retrospective review of a multi-institutional shoulder arthroplasty database was performed between 2001 and 2021. We identified 5,704 postoperative visits from 1,164 aTSAs performed for glenohumeral osteoarthritis with an intact rotator cuff with minimum 2-year follow-up. Patients were excluded for a preoperative diagnosis of nerve injury, infection, or fracture. Postoperative complications that would affect range of motion were also eliminated (postoperative rotator cuff tear, subscapularis failure, fracture, infection, Lazarus grade 4 or 5 glenoid radiolucency, revision surgery and neurological injury). Patients were included if they had a minimum of three follow-up visits meeting the following: (1) between 3-6 months, (2) minimum 2-year follow-up, and (3) follow-up at any other time. Our primary outcome was the rate of recovery in ROM in abduction, forward elevation (FE), internal rotation (IR), and external rotation (ER). Secondarily, we evaluated the rate of recovery in patient outcome scores (SST, Constant, ASES, UCLA, SPADI, SAS scores). Continuous two-phase segmented linear regression models with patient-specific random intercepts were fitted to the data separately for each outcome measure and stiffness group. Patients were modeled with random intercepts to account for the correlation between repeated measures from the same individuals.

RESULTS:

Of the 1,164 aTSA included, 172 (14.8%) were stiff preoperatively. The mean age was 66.3 years (SD 8.1) and 48.6% (N = 566) were female. Most recovery of ROM slowed >1.5-times later in stiff versus non-stiff shoulders for abduction (8.1 vs. 4.6 months postoperatively), IR (6.8 vs. 4.5 months postoperatively), and ER (8.7 vs. 4.0 months postoperatively) (**Figure 1 and Table 1**). In contrast, most recovery in FE for stiff and non-stiff shoulders slowed at the same time (4.4 vs. 4.3 months postoperatively). Similarly, a slower early recovery rate was observed for stiff versus non-stiff shoulders in abduction (4.9 vs. 14.0 °/month), IR (0.3 vs. 0.5 points/month), and ER (3.1 vs. 9.1 °/month); however, a similar rate was observed for FE (16.9 vs. 16.6 °/month). Regarding outcome scores, most recovery in non-stiff shoulders slowed between 3.9 to 4.6 months postoperatively (**Figure 2 and Table 2**). While stiff shoulders similarly reached a maximal outcome in the SST score in 4.6 months, the remaining scores ranged between 6.9 to 7.5 months postoperatively. Stiff shoulders recovered at roughly half the rate of non-stiff shoulders for all outcomes, except for the SST (1.6 vs. 1.9 °/month).

DISCUSSION AND CONCLUSION:

Patients with limited preoperative ER and rotator cuff intact glenohumeral osteoarthritis have slower recovery in abduction, ER and IR compared with preoperatively non-stiff shoulders in aTSA. Despite slower recovery, aTSA patients with limited preoperative ER ultimately achieve similar IR, Constant scores, and SAS scores to non-stiff shoulders.

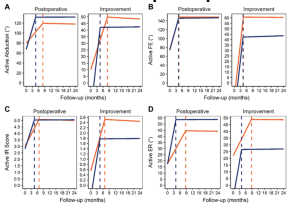


**Figure 1.** Two-segment continuous linear regression models with patient-specific random intercepts for stiff (orange) and non-stiff (blue) shoulders depicting the relationship between follow-up time and postoperative values and improvement (postoperative minus preoperative value) in active abduction (A), active FE (B), IR score (C), and active ER (D). Changepoints are depicted by dashed lines. ER, external rotation; FE, forward elevation; IR, internal rotation.

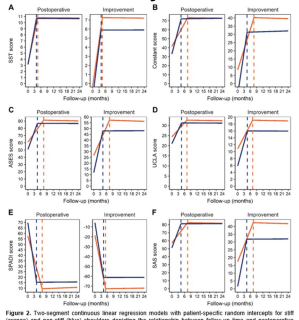


**Figure 2.** Two-segment continuous linear regression models with patient-specific random intercepts for stiff (orange) and non-stiff (blue) shoulders depicting the relationship between follow-up time and postoperative values and improvement (postoperative minus preoperative value) in the SST (A), Constant (B), ASES (C), UCLA (D), SPADI (E), and SAS (F) scores. SST, Simple Shoulder Test; ASES, American Shoulder and Elbow Surgeons Score; UCLA, University of California, Los Angeles; SPADI, Shoulder Pain and Disability Index; SAS, Shoulder Arthroplasty Smart.

**Table 1.** Range of motion model estimates from continuous two-phase linear regression models with random intercepts representing subjects.

| Outcome measure | Model parameter | Postoperative | | Improvement | |
|---|---|---|---|---|---|
| | | Stiff | Non-Stiff | Stiff | Non-Stiff |
| Active Abduction (°) | Intercept (°) | 79.8 | 67.4 | 10.1 | -22.3 |
| | Early (°/mo.) | 4.9 | 14.0 | 4.9 | 14.0 |
| | Late (°/mo.) | -0.1 | 0.0 | -0.1 | 0.0 |
| | Changepoint (mo.) | 8.1 | 4.6 | 8.1 | 4.6 |
| Active FE (°) | Intercept (°) | 73.7 | 75.0 | -13.3 | -28.8 |
| | Early (°/mo.) | 16.9 | 16.6 | 16.7 | 16.7 |
| | Late (°/mo.) | 0.0 | 0.1 | 0.0 | 0.1 |
| | Changepoint (mo.) | 4.4 | 4.3 | 4.4 | 4.3 |
| Active IR score | Intercept (points) | 3.0 | 2.8 | 0.5 | -0.5 |
| | Early (points/mo.) | 0.3 | 0.5 | 0.3 | 0.5 |
| | Late (points/mo.) | 0.0 | 0.0 | 0.0 | 0.0 |
| | Changepoint (mo.) | 6.8 | 4.5 | 6.8 | 4.5 |
| Active ER (°) | Intercept (°) | 17.6 | 17.3 | 21.9 | -9.7 |
| | Early (°/mo.) | 3.1 | 9.1 | 3.1 | 9.1 |
| | Late (°/mo.) | 0.0 | 0.0 | 0.0 | 0.0 |
| | Changepoint (mo.) | 8.7 | 4.0 | 8.7 | 4.0 |

ER, external rotation; FE, forward elevation; IR, internal rotation.

**Table 2.** Outcome score model estimates from continuous two-phase linear regression models with random intercepts representing subjects.

| Outcome measure | Model parameter | Postoperative | | Improvement | |
|---|---|---|---|---|---|
| | | Stiff | Non-Stiff | Stiff | Non-Stiff |
| SST score | Intercept (°) | 3.3 | 3.1 | -0.3 | -1.8 |
| | Early (°/mo.) | 1.6 | 1.9 | 1.6 | 1.9 |
| | Late (°/mo.) | 0.0 | 0.0 | 0.0 | 0.0 |
| | Changepoint (mo.) | 4.6 | 3.9 | 4.6 | 3.9 |
| Constant score | Intercept (°) | 41.5 | 33.0 | 8.4 | -6.8 |
| | Early (°/mo.) | 4.3 | 8.9 | 4.1 | 8.5 |
| | Late (°/mo.) | 0.0 | 0.0 | 0.0 | 0.0 |
| | Changepoint (mo.) | 7.5 | 4.4 | 7.8 | 4.5 |
| ASES score | Intercept (°) | 60.8 | 50.8 | 26.7 | 11.8 |
| | Early (°/mo.) | 4.0 | 8.0 | 4.1 | 8.3 |
| | Late (°/mo.) | -0.1 | 0.0 | -0.1 | 0.0 |
| | Changepoint (mo.) | 7.5 | 4.5 | 7.5 | 4.3 |
| UCLA score | Intercept (°) | 24.3 | 21.0 | 10.8 | 5.9 |
| | Early (°/mo.) | 1.2 | 2.2 | 1.2 | 2.2 |
| | Late (°/mo.) | 0.0 | 0.0 | 0.0 | 0.0 |
| | Changepoint (mo.) | 7.2 | 4.6 | 7.1 | 4.6 |
| SPADI score | Intercept (°) | 57.7 | 69.7 | -16.5 | -5.7 |
| | Early (°/mo.) | -7.0 | -12.9 | -10.5 | -13.3 |
| | Late (°/mo.) | 0.1 | 0.0 | 0.0 | 0.0 |
| | Changepoint (mo.) | 6.9 | 4.2 | 5.2 | 4.2 |
| SAS score | Intercept (°) | 57.2 | 51.1 | 17.4 | 1.5 |
| | Early (°/mo.) | 3.4 | 6.9 | 3.4 | 7.1 |
| | Late (°/mo.) | 0.0 | 0.0 | 0.0 | 0.0 |
| | Changepoint (mo.) | 7.5 | 4.3 | 7.4 | 4.3 |

SST, Simple Shoulder Test; ASES, American Shoulder and Elbow Surgeons Score; UCLA, University of California, Los Angeles; SPADI, Shoulder Pain and Disability Index; SAS, Shoulder Arthroplasty Smart.