J Shoulder Elbow Surg (2017) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

The influence of anatomic total shoulder arthroplasty using a subscapularis tenotomy on shoulder strength

Keith M. Baumgarten, MD[a,b,*], Roy Osborn, PT, DPT, MS[b], Will E. Schweinle Jr, PhD[b], Matthew J. Zens, DPT, SCS, MS, ATC[a]

[a]*Orthopedic Institute, Sioux Falls, SD, USA*
[b]*University of South Dakota, Vermillion, SD, USA*

Background and Hypothesis: There is limited evidence describing the influence of total shoulder arthroplasty on strength. The hypothesis was that after total shoulder arthroplasty, strength would improve compared with the preoperative state but remain inferior to that of the nonoperative shoulder. An additional aim was to determine whether strength improvement was associated with improvements in outcome scores and motion.
Materials and methods: Thirty-six patients underwent total shoulder arthroplasty, with 31 patients (86%) having 1 year of follow-up for all outcomes. Patient-determined outcomes (Western Ontario Osteoarthritis of the Shoulder score; Disabilities of the Arm, Shoulder and Hand score; Single Assessment Numeric Evaluation rating; and shoulder activity level), range of motion, and strength were assessed. Isometric strength was determined for scaption and external rotation, as well as the liftoff test, belly-press test, and bear-hug test.
Results: All strength measures improved, with significant increases in external rotation, the liftoff test, and the bear-hug test, but remained inferior to the nonoperative-side strength. Improved strength in the belly-press test was associated with greater improvement in Single Assessment Numeric Evaluation scores. Improvements in scaption and belly-press testing were associated with improvements in active flexion. Strength improvements in the liftoff test were associated with improved internal rotation in 90° of abduction. Patients with improvements in strength had improvements in their shoulder activity level from baseline to final follow-up, whereas patients without improved strength test findings did not have improved shoulder activity levels.
Conclusions: Total shoulder arthroplasty improved external rotation, liftoff, and bear-hug strength testing. Operative shoulder strength remained inferior to strength of the nonoperative shoulder. Patients with improvements in strength were more likely to have greater improvements in outcome scores and range of motion. Improvements in the shoulder activity level after anatomic total shoulder arthroplasty may be dependent on improvements in strength.
Level of evidence: Level I; Prospective Design; Prognosis Study

Keywords: Shoulder; osteoarthritis; anatomic total shoulder arthroplasty; strength; subscapularis; tenotomy

It is well known that pain relief and range of motion are improved with anatomic total shoulder arthroplasty. However, there are few data that have revealed the influence of total shoulder arthroplasty on strength after surgery.[28] It is important

Institutional review board approval: Avera 2011.115.
*Reprint requests: Keith M. Baumgarten, MD, Orthopedic Institute, 810 E 23rd St, Sioux Falls, SD 57117, USA.
E-mail address: Kbaumga@yahoo.com (K.M. Baumgarten)

1058-2746/$ - see front matter © 2017 Journal of Shoulder and Elbow Surgery Board of Trustees. All rights reserved.
http://dx.doi.org/10.1016/j.jse.2017.06.043

to examine the influence of total shoulder arthroplasty on strength to appropriately counsel patients regarding expectations following surgery.

When total shoulder arthroplasty is performed, the most common approaches involve accessing the glenohumeral joint through the subscapularis tendon and require subscapularis repair once the prosthesis has been implanted. The most common approaches to total shoulder arthroplasty include tenotomy, subscapularis peel, and lesser tuberosity osteotomy.[8,16] Currently, there is no consensus as to which technique of subscapularis management is superior. Although the technique is controversial, Caplan et al[8] suggested that the tendon-to-tendon repair associated with tenotomy is simple and quick, avoids the possibility of osteotomy nonunion, and showed a high rate of normal subscapularis function.

Our study examined a prospectively followed up cohort of patients undergoing anatomic total shoulder arthroplasty by a subscapularis tenotomy approach with tendon-to-tendon repair. The purposes of this study were (1) to examine the influence of anatomic total shoulder arthroplasty on patients' strength and (2) to determine whether strength improvement was associated with patients' outcomes. The primary hypothesis of this study was that anatomic total shoulder arthroplasty using a subscapularis tenotomy with subsequent tendon-to-tendon repair would result in an improvement in patients' strength. The secondary hypothesis was that the postoperative strength after anatomic total shoulder arthroplasty would remain inferior compared with the nonoperative side.

Materials and methods

Patients undergoing primary, anatomic total shoulder arthroplasty for the treatment of glenohumeral osteoarthritis were enrolled in a prospective cohort study. Patients who had rotator cuff tears or rotator cuff tear arthropathy, a history of shoulder fracture, or inflammatory arthropathy and those who required revision surgery were excluded. In addition, patients with significant, symptomatic cervical spine pathology were excluded.

Patient outcomes comprised (1) patient-determined outcome scores including the Disabilities of the Arm, Shoulder and Hand (DASH) score,[14] Western Ontario Osteoarthritis of the Shoulder (WOOS) score,[21] shoulder activity level,[6] and Single Assessment Numeric Evaluation (SANE) rating[29]; (2) range of motion; and (3) strength. Patient outcome scores were determined prospectively at baseline preoperatively and at 6 weeks, 12 weeks, 6 months, and 12 months postoperatively. Range of motion was determined at baseline and at 12 weeks, 6 months, and 12 months postoperatively. Strength was determined at baseline and at 6 months and 12 months postoperatively. Outcome determination was performed by 1 of 2 experienced physical therapists (R.O. and M.J.Z.).

Range-of-motion measurements were performed on both the operative and nonoperative shoulders with a standard goniometer and included the following: active and passive flexion in the supine position; standing active flexion; active and passive external rotation in the neutral position; active and passive external rotation in the 90° abducted position; active and passive internal rotation in the 90° abducted position; internal rotation behind the back measuring the distance of the distal tip of the thumb from the spinous process of C7 in centimeters; and active and passive horizontal, cross-body adduction, which was determined by measuring the minimal distance from the antecubital fossa to the contralateral, anterolateral acromion when the arm was adducted horizontally across the body.[4] With maximal cross-body adduction, the patient was asked to rank his or her pain on an ordinal scale from 1 to 10, with 1 being no pain and 10 being the worst pain.

Strength testing was performed on both the operative and nonoperative shoulders in the seated position for all tests except the liftoff test. Assessment of scaption was performed with the thumb up to test the supraspinatus. External rotation strength was assessed in the neutral position with the patient's arm at the side to test the infraspinatus. Subscapularis strength was tested in 3 separate positions. These tests included the liftoff test,[12] belly-press test,[12] and bear-hug test.[5] A handheld dynamometer was used to measure isometric strength objectively. The handheld dynamometer has been validated for use in subscapularis evaluation with excellent reliability.[18,20]

All surgical procedures were performed in the modified beach-chair position. A standardized deltopectoral approach was performed. The subscapularis and posterosuperior rotator cuff were visually examined to ensure there was no evidence of rotator cuff tears. A subscapularis tenotomy was performed leaving at least 1 cm of subscapularis tendon intact on the lesser tuberosity to facilitate repair once the prosthesis was implanted. All subscapularis tenotomies were repaired using a tendon-to-tendon technique with 6 No. 2 FiberWire sutures (Arthrex, Naples, FL, USA) in a Mason-Allen fashion. All patients were placed in a sling postoperatively for 6 weeks to protect the subscapularis repair. Physical therapy was initiated in a standardized fashion but included limitation of passive external rotation to 30° for the first 6 weeks to help protect the subscapularis repair (Appendix 1).

Data analysis consisted of (1) assessing changes in outcomes from baseline to final follow-up and (2) assessing between-group differences with the 2-tailed Student *t* test. The level of significance was set at .05.

Results

We included 36 patients (20 men and 16 women) who underwent total shoulder arthroplasty. The mean age of patients was 70.3 ± 10.6 years (range, 42-86 years). Of the patients, 58% (21 of 36) underwent surgery on their dominant side. In 31 of 36 patients (86%), 1 year of follow-up was available for all outcomes including (1) patient-determined outcome scores, (2) range of motion, and (3) strength (1 patient was lost to follow-up, 1 patient was diagnosed with cancer and did not want to return, and 3 patients stated they did not want to return for an evaluation). Of the 36 patients, 33 (91%) were able to submit their patient-determined outcome scores at 1 year of follow-up.

There was a statistically significant improvement from baseline to final 1-year follow-up ($P < .0001$) in the DASH, WOOS, and SANE scores (Fig. 1, *A-C*). The shoulder activity level demonstrated a trend toward improvement from baseline to final 1-year follow-up ($P = .07$) (Fig. 1, *D*). For all