J Shoulder Elbow Surg (2016) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

The influence of patient- and surgeon-specific factors on operative duration and early postoperative outcomes in shoulder arthroplasty

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Background: Increased operative duration has been shown to have demonstrable effects on the outcomes and complications in multiple areas of orthopedic surgery. We sought to determine if patient- and surgeon-specific factors correlated to operative duration in shoulder arthroplasty. Our hypothesis was that increased surgeon and trainee volume would decrease operative times and that more complex pathology would increase operative duration.

Methods: A retrospective review of primary and revision total and reverse shoulder arthroplasties performed at a single institution from 2012 through 2015 was performed evaluating the correlation between specific patient and surgeon factors and operative duration. The influence of operative duration on postoperative length of stay and risk of readmission within 30 days was also analyzed.

Results: For surgeon-specific factors, high surgeon volume (>30 shoulder arthroplasties/year) was associated with shorter operative duration (105.9 vs. 128.3 minutes; $P < .001$). Progression through the fellowship academic year was found to be associated with decreased surgical times (100.7 vs. 116.5 minutes; $P < .0001$). Certain complex pathologic processes (reverse shoulder arthroplasty for sequelae of prior fracture, total shoulder arthroplasty for dysplastic glenoid morphology, revision surgery) showed increased operative times. Patients with postoperative readmission had a longer mean operative time (163 vs. 107.1 minutes).

Conclusions: Increased surgeon and trainee volumes were associated with decreased operative duration in shoulder arthroplasty. Patients with more complex pathology were more likely to have increased surgical times. Postoperative readmission within 30 days was associated with increased operative duration. Consideration of patient selection by surgeons to minimize operative times may reduce readmissions.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Reverse shoulder arthroplasty; revision; surgery; total shoulder arthroplasty; complications; surgeon volume; postoperative outcome

This study was determined to be exempt from review by the Western Institutional Review Board.

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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.2016.10.025

Operative efficiency is a goal of all surgeons. Increased operative duration has been associated with increased costs and increased risk of perioperative complications in both the orthopedic and nonorthopedic surgical literature. The influence of patient- and surgeon-specific characteristics on operative duration in shoulder arthroplasty or the influence of operative duration on the risk of early postoperative complications after shoulder arthroplasty has not been well described.

The general surgery and obstetric-gynecologic surgical literature has multiple examples of the influence of operative time on surgical outcomes. Operative duration correlated with increased complications in general, vascular, colorectal, and plastic surgery.[4-6,14,18] Lower surgeon volume correlated with increased operative duration and length of stay in laparoscopic bariatric surgery.[12] Increased operative duration correlated with preoperative morbidity and increased risk of surgical and medical complications in hysterectomy surgery.[3]

Within orthopedics, increased operative duration has been shown to have significant effects on the outcomes of hip and knee arthroplasty as well as of spine surgery and revision shoulder arthroplasty. Increased surgical duration has been shown to increase infection rates in total knee arthroplasty as well as to have increased risk of wound problems and prolonged hospital stay in total hip arthroplasty.[10,11,13,15,19] Increased operative time has been associated with increased infection risk with increased operative time in 1-level lumbar fusions.[8]

Within shoulder surgery, large retrospective database reviews have shown improved perioperative outcomes for patients undergoing surgery both in higher volume hospitals and with higher volume surgeons.[7,17] Higher volume surgeons have also been shown to have significantly shorter operative times than low-volume surgeons for shoulder hemiarthroplasty, anatomic total shoulder arthroplasty (TSA), and reverse shoulder arthroplasty (RSA).[7] Whereas these studies have associated improved operative times and perioperative outcomes with increased surgeon volume for shoulder arthroplasty, the effect of high-volume fellowship training has not been well quantified in the literature.

In this study, we hypothesized that operative time in patients undergoing shoulder arthroplasty would vary and be dependent on both surgeon factors (surgeon volume, progression through an academic calendar year, type of subspecialty fellowship training) and patient factors (age, sex, body mass index [BMI], type of shoulder arthroplasty, history of prior surgery, glenoid morphology). In addition, early postoperative outcomes were analyzed to determine if there is a relationship between operative time and early postoperative outcomes including length of stay, risk of allogeneic blood transfusion, and risk of complications or readmission within 30 days after discharge.

Methods

A retrospective cohort study was performed by reviewing the electronic medical record (EMR) of a single tertiary care hospital to identify patients who underwent primary or revision TSA or RSA at our institution between June 25, 2012, and February 25, 2015. We identified 636 patients who underwent 636 shoulder arthroplasties. One case was excluded from the study because this polytraumatized patient underwent additional surgical procedures including open reduction–internal fixation of bilateral proximal tibia fractures during the same anesthetic event as her RSA for fracture. Adequate data were available for the remaining 635 procedures, which formed the basis of our study. We recorded patient-specific characteristics including age, sex, BMI, side of procedure, preoperative range of motion (from outpatient records), and history of prior surgery.

Surgeon-specific characteristics included primary surgeon shoulder arthroplasty volume and the degree of progression through the academic calendar year at the time of surgery. Surgeon shoulder arthroplasty volume was determined by querying our institution's billing software (FileMaker Pro; dbServices, Indianapolis, IN, USA) for the number of procedures billed under *Current Procedural Terminology* codes 23472, 23473, and 23474. Surgeons were categorized either "high volume" or "low volume" on the basis of whether they had performed an average of 30 or more shoulder arthroplasties per year; 30 cases per year was chosen to discriminate high- vs. low-volume surgeons on the basis of the average number of cases per year for the high-volume surgeon group in a large, previously published study analyzing surgeon and hospital volume effects on perioperative quality metrics.[17] The calendar month during which the surgery was performed was also recorded as each of the primary surgeons works with either shoulder/elbow or hand/upper extremity surgical fellows as part of their practice and date of surgery could serve as a surrogate for fellow experience during the study period. Surgeries were divided into 4 categories by date; block 1 corresponded with the first 3 months of fellowship (August through October), block 2 was the following 3 months (November through January), block 3 was the next 3 months (February through April), and block 4 consisted of the final 3 months of fellowship (May through July).

On the basis of the type of procedure, we divided the patients into 3 groups for statistical analysis: group 1 consisted of patients who underwent primary TSA; group 2 consisted of patients who underwent primary RSA; and group 3 consisted of revision arthroplasty, which was defined as any TSA or RSA performed in patients with a prior TSA, RSA, or humeral hemiarthroplasty or resurfacing.

Within group 1, the cases were further subdivided on the basis of glenoid morphology using the Walch classification.[16] Within group 2, cases were subdivided on the basis of the indication for surgery. For each of these cases, the preoperative and postoperative radiographs as well as preoperative outpatient medical records and operative reports were reviewed, and the cases were then categorized as being performed for cuff tear arthropathy, massive cuff tear without arthritis, arthritis with intact rotator cuff, acute fracture, sequelae of previous fracture, or chronic shoulder instability. The arthritis with intact rotator cuff group consisted mainly of patients with glenoid bone loss precluding anatomic arthroplasty, such as patients with inflammatory arthropathy or eccentric osteoarthritis (Walch B2 or C glenoid morphology). The fracture sequelae group consisted of patients with nonunion, malunion, avascular necrosis, or failed open reduction–internal fixation of a proximal humerus fracture. Patients with failed humeral hemiarthroplasty for fracture were included in the revision arthroplasty group (group 3).

Operative duration ("cut to close" time or CtC) was calculated using the incision and closure times recorded by the circulating nurse in the EMR. Total time in the operating room (OR) was calculated