New preoperative planning technologies in 8117 elective shoulder arthroplasty procedures: trends and outcomes

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INTRODUCTION:

Ongoing innovation has led to a continuous influx of new technologies related to shoulder arthroplasty. These are made available to surgeons and marketed to both healthcare providers and patients as methods to potentially improve the outcomes of shoulder arthroplasty. However, post-market surveillance on the adoption of new technologies and their outcomes, outside of controlled trials in community settings, is often limited. More recently, many of these involve preoperative planning technologies directed at improving the durability of the glenoid component. The goal of this study is to understand how these technologies are being adopted by surgeons over time, as well as evaluate how these technologies affect outcomes for patients undergoing shoulder arthroplasty in a large US-based healthcare system.

METHODS:

A cohort study was conducted using data from a US integrated health care system's shoulder arthroplasty registry (a surveillance tool with 100% coverage that records information on patient-, procedure-, implant-, surgeon- and hospital-related variables). Patients aged ≥18 years who underwent primary elective anatomical total shoulder or reverse total shoulder arthroplasty were identified (2015-2020). Preoperative planning technologies were the exposure of interest and identified as (1) a CT scan as a proxy for preoperative planning software utilization and (2) patient-specific instrumentation (PSI) computer software systems supported by implant manufacturer since 2015 for TSA and since 2017 for RTSA. During this time, there was no separate cost for use of PSI within the organization.

Utilization of extensive preoperative planning technologies within the healthcare system across operative years is described. Cox proportion hazard regression was used to evaluate risk of aseptic revision and logistic regression was used to evaluate likelihood of 90-day adverse events (including emergency department [ED] visit, readmission, deep infection, and venous thromboembolism [VTE]) for procedures where preoperative planning technologies were used to procedures where conventional radiography preoperative planning was used. Regression models included age, gender, body mass index, American Society of Anesthesiologist's classification, Elixhauser's comorbidity burden, procedure type, Walch glenoid classification, and utilization of upper extremity walking aids as covariates. A cluster term was also included in the regression model to adjust for surgeon differences. Hazard ratios (HR) for longitudinal outcomes, odds ratios (OR) for binary outcomes, and 95% confidence intervals (CI) are presented; a $p<0.05$ was considered statistically significant.

RESULTS:

The study sample included 8117 procedures performed by 130 surgeons at 40 hospitals. The mean age was 70.6 years and 44.7% (n=3630) were male. Utilization of preoperative CT scans grew steadily in 2015 to 2017 with a peak of 36% for TSA and 42% for RTSA in 2017, then declined to 20 and 28% in 2020, respectively. PSI increased from 1% in 2015 to 25% in 2020 for TSA and 5% in 2017 to 16% in 2020 for RTSA.

Patients with preoperative CT scans (31%, n=2527) had a higher proportion of Walch type B or C native glenoid and a longer operative time (+13 minutes), all other characteristics and surgeon volume were similar between preoperative planning and conventional planning groups. We found no significant difference in aseptic revision risk during follow-up (HR=1.22, 95% CI=0.87-1.72, p=0.257). Patients with preoperative CT scans had a lower likelihood of 90-day ED visit (OR=0.84, 95% CI=0.73-0.97, p=0.021) but a higher likelihood of 90-day VTE (OR=1.79, 95% CI=1.18-2.74, p=0.007) (**Table 1**).

Patients who received PSI (11%, n=400) were more likely to be male, with a higher frequency of Walch type B or C native glenoid, have a longer operative time (+10 mins), and were operated on by higher volume surgeons (+17 procedures yearly). Of those without PSI, 28% (n=875) still had a preoperative CT scan. No significant difference in aseptic revision risk during follow-up was observed (HR=1.37, 95% CI=0.73-2.58, p=0.328), but patients who received PSI had a higher likelihood of 90-day deep infection (OR=6.25, 95% CI=1.10-35.32, p=0.038) compared to patients without PSI (**Table 2**).

DISCUSSION AND CONCLUSION:

We observed a trend of increasing use of preoperative CT scans for shoulder arthroplasty that peaked in 2017, while utilization of PSI has continued to increase. We found no difference in the risk for aseptic revision but further study with longer follow up is required to discern if these technologies add longer-term value to patient care. The findings of higher likelihood of VTE and deep infection associated with CT and PSI use, respectively, warrant further study. Cost-effectiveness studies are needed to discern whether these technologies add value to patient care.

Table 1. Crude incidence of events* and adjusted risk following primary shoulder arthroplasty with and without preoperative computerized tomography (CT) scans.

Outcome	CT scan (N=2527)	No CT scan (N=5590)	Adjusted estimate (95% CI)	P
Longitudinal event				
Aseptic Revision	1.8%* (44)	1.4%* (71)	1.22 (0.87-1.72)	0.257
90-day events				
ED visit	11.6% (293)	13.8% (769)	0.84 (0.73-0.97)	**0.021**
Readmission	4.2% (105)	4.3% (238)	1.01 (0.80-1.29)	0.915
Deep infection	0.1% (2)	0.2% (10)	0.44 (0.10-2.03)	0.296
VTE	1.5% (39)	0.9% (48)	1.79 (1.18-2.74)	**0.007**

CI=confidence interval. CT=computerize tomography. ED=emergency department. VTE=venous thromboembolism.

* % calculated as 1 minus the Kaplan-Meier estimate at 1-year follow-up for aseptic revision and n/N for 90-day events.

Table 2. Crude incidence of events* and adjusted risk following primary shoulder arthroplasty with and without patient-specific instrumentation.

Outcome	PSI (N=400)	No PSI (N=3153)	Adjusted estimate (95% CI)	P
Longitudinal event				
Aseptic Revision	6 (1.8)	37 (1.3)	1.44 (0.71-2.92)	0.311
90-day events				
ED visit	40 (10.0)	393 (12.5)	0.76 (0.54-1.08)	0.130
Readmission	18 (4.5)	114 (3.6)	1.58 (0.92-2.74)	0.099
Deep infection	**2 (0.5)**	**2 (0.1)**	**7.74 (1.11-53.94)**	**0.039**
VTE	4 (1.0)	33 (1.0)	0.82 (0.29-2.32)	0.709

CI=confidence interval. ED=emergency department. PSI=patient specific instrumentation. VTE=venous thromboembolism.

* % calculated as 1 minus the Kaplan-Meier estimate at 1-year follow-up for aseptic revision and n/N for 90-day events.