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Optimizing follow-up after anatomic total shoulder arthroplasty

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Background: With increases in both total shoulder arthroplasty (TSA) volumes and patient life expectancies, the number of patients requiring follow-up after shoulder arthroplasty continues to grow exponentially. The purpose of this study is to establish a data-based follow-up schedule minimizing unnecessary patient and health care system costs without sacrificing patient care.

Methods: Between January 1975 and January 2013, 2786 consecutive anatomic TSAs were performed at our institution. All shoulders undergoing reoperation/revision were reviewed to identify the common modes of failure and times to failure.

Results: A total of 208 shoulders (7.5%) required reoperation. Early failure mechanisms included instability, rotator cuff tears, and infection, with 63% of these reoperations occurring within 2 years. Later failures included mechanical failures (including component loosening) and periprosthetic fractures, with no identifiable peak occurrence. After 2 years, TSA failed at an average rate 1.1% per year.

Conclusions: TSA failure after 2 years is uncommon and triggers surgical intervention in approximately 1% of patients per year. Routine in-person surveillance of all patients on a scheduled basis may not be necessary and would increase patient and other health care costs. We recommend in-person visits to assess healing, direct rehabilitation, and manage soft tissue or infectious issues until 2 years, with planned, periodic patient contact by mail and radiographic evaluation of patients with poor or worsening outcomes thereafter, unless patient concerns arise or a newer implant design warrants closer clinical assessment.

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

Keywords: total shoulder arthroplasty; follow-up; shoulder; lower extremity arthroplasty; TSA; anatomic total shoulder arthroplasty

Total shoulder arthroplasty (TSA) volumes continue to increase rapidly, similar to the lower extremity arthroplasty population.[2,3] From 2011 to 2030, the demand for shoulder arthroplasty is projected to increase by 750%.[6] The combination of increased arthroplasty volumes, decreasing mean patient age at index arthroplasty, and longer life expectancy has the

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potential to overload the clinic schedule of orthopedic surgeons with patients returning for routine follow-up, whose time would be better allocated toward patient problems requiring more immediate attention. In the era of cost-conscious medicine, surgeons have an obligation to optimize the use of patient, insurance, health care facilities, and surgical team resources. However, surgeons should not sacrifice postoperative care, rehabilitation, diagnosis and management of complications, and monitoring of new and emerging implant systems. To meet demand and manage costs, surgeons may need to reconsider the routine postoperative follow-up schedule after operations that traditionally perform well over the long-term.

Surgical follow-up after arthroplasty is largely based on surgeon preference, without scientific data to support these schedules.[7] Most routine follow-up visits result in no change in patient management, with the patient being asked to return at the next surgeon-preferred interval. Our institution's protocol for shoulder arthroplasty has been follow-up visits at 6 weeks, 3 months, 1 year, 2 years, 5 years, and every 5 years thereafter. The burden of travel and cost of the visit may not be inconsequential to patients, especially at tertiary referral centers where patients often travel a distance to see their surgeon. We hypothesize that our regimented follow-up schedule is not fully necessary and overly burdensome, because the vast majority of visits do not alter patient care.

To create a patient-centered follow-up schedule, it is important to understand the most common modes of failure with their corresponding time to failure. With this information, we propose changing our in-person follow-up schedule to eliminate unnecessary patient visits, which will lead to less clinical schedule burden and decrease patient costs over the long-term.

Materials and methods

Between January 1975 and January 2013, 3412 consecutive primary anatomic TSAs were performed at our institution. Three patients with a TSA requested to be removed from the research. One TSA was performed for oncologic resection/reconstruction and was excluded. Also excluded were 622 TSAs performed with metal-back components, which had documented poor clinical track record. This left 2786 TSAs available for inclusion in this study. The shoulder operations were performed at an average age of 63 years (range, 17-93 years) in 1496 women (53.7%) and 1290 men (46.3%). The number of operations increased over time, with fewer than 50 cases per year from 1975 to 1994. This increased to 50 to 100 cases per year between 1995 and 2002, with more than 100 cases per year being performed after 2003. Increases were due to increased patient demand and hiring additional surgeons to meet this demand.

All shoulders are monitored by our institutional Joint Registry Database. Patients were invited to return in person to see their surgeon at 6 weeks, 3 months, 1 year, 2 years, 5 years, and every 5 years thereafter. The 1552 patients (56%) who did not return for in-person follow-up at the time of last contact were evaluated by letter or phone to assess their shoulder and determine whether they had undergone any interval procedures or reoperations at other institutions that would not have otherwise been captured in our medical record. Shoulders were monitored until reoperation or last patient contact. Mean follow-up was 6.4 years (range, 0.1-35.4 years).

The most common diagnosis was primary osteoarthritis (1970 shoulders). Other diagnoses included inflammatory arthritis (n = 310), post-traumatic arthritis (n = 301), osteonecrosis (n = 102), cuff tear arthropathy (n = 76), and other (n = 27). Implants used were Richards/Smith & Nephew (Memphis, TN, USA) in 1435, Biomet (Warsaw, IN, USA) in 618, 3M (St. Paul, MN, USA) in 232, Tornier (Bloomington, MN, USA) in 163, Stryker (Mahwah, NJ, USA) in 159, DePuy (Warsaw, IN, USA) in 74, and not recorded in 105. All glenoid components were cemented. Humeral components were placed with a press fit technique in 2438 and cemented in 348 cases.

Statistical analysis

All shoulders undergoing reoperation/revision were identified, and their records were reviewed to identify the mode of failure. The group, as a whole, was evaluated using Kaplan-Meir survival curves with 95% confidence intervals. The most common failure mechanisms were evaluated in the same manner. The mean, median, and interquartile range (IQR) for time to failure was determined. To determine when TSAs were likely to fail, the conditional probability of failure was calculated at 1-year intervals providing an actuarial method of TSA survival. This was determined by dividing the number of reoperations per year by the total number of TSAs performed during the same interval. This allows for failure to be evaluated in reference to time, rather than in reference to an event, as it is done with the Kaplan-Meir method.

Results

During the study interval, 208 shoulders (7.5%) underwent reoperation. Reoperations occurred at a mean of 5.3 years (range, 1 day-26 years). The most common failure mechanism was instability, resulting in 89 reoperations (3.2%). Mechanical failures accounted for 85 reoperations (3.1%) and included aseptic loosening, component wear, and implant fracture. Other modes of failure resulting in reoperation included rotator cuff tears in 45 (1.6%), infection in 32 (1.1%), and periprosthetic fracture in 17 (0.6%). Reoperations are depicted over time in Fig. 1 using the Kaplan-Meir method. Note the steepness of the curve, which occurs over the first 2 years postoperatively, before flattening out with a gradual decline in TSA survival over time.

The median time to reoperation for all TSAs was 3.9 years (IQR, 0.6-8.7 years), and 40% of reoperations, for all causes, occurred within the first 2 years. Reoperation for instability occurred at a median of 0.7 years (IQR, 0.2-2.3 years) and mean of 2.3 years (range, 0-16.5 years); mechanical failures occurred at a median of 6.1 years (IQR, 3.9-9.6 years) and mean of 7.3 years (range, 0.1-26.2 years); rotator cuff reoperations occurred at a median of 1.1 years (IQR, 0.3-4.7 years) and mean of 3.0 years (range, 0.1-12.1 years); infection occurred at a median of 2.5 years (IQR, 0.2-8.2 years) and mean of 4.6 years (range, 0.04-16.5 years); and periprosthetic fractures occurred at a median of 8.9 years (IQR, 5.4-9.9 years) and mean of 8.6 years (range, 0-20.4 years).

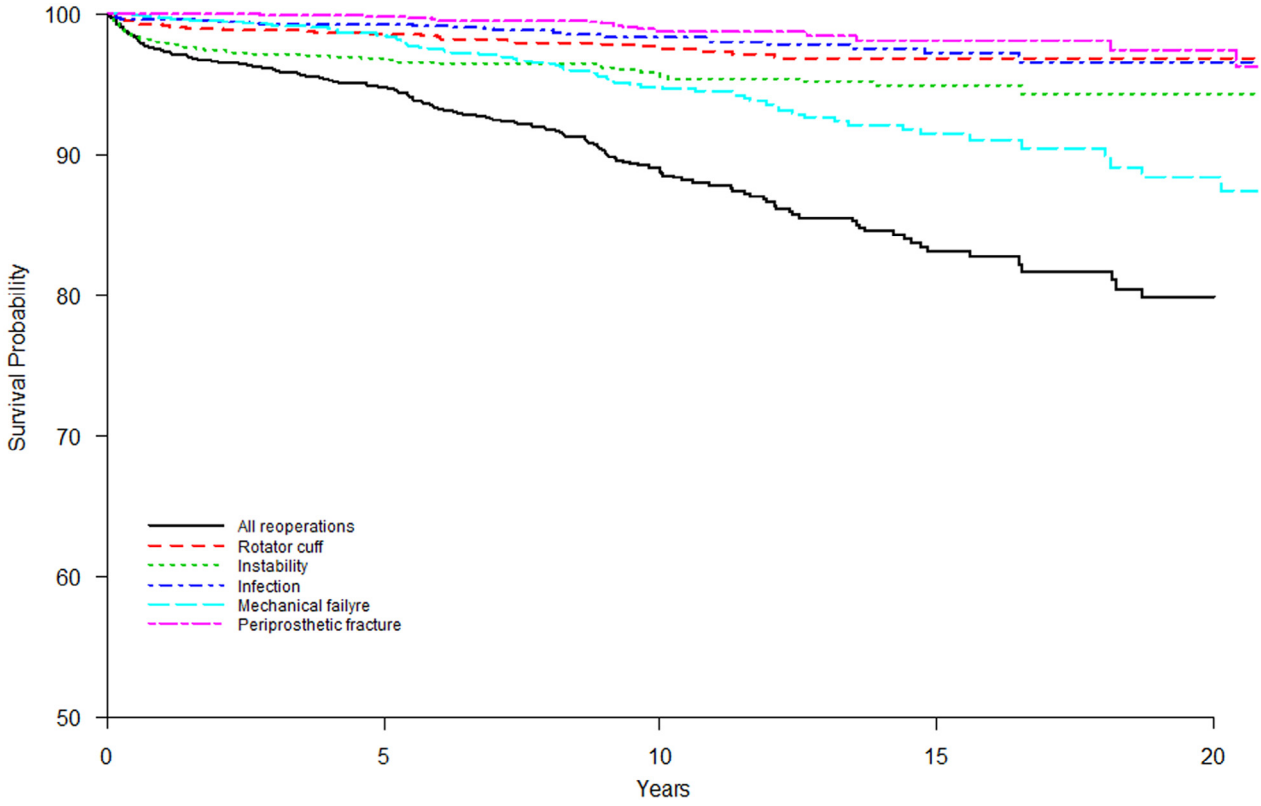

Figure 1 Reoperations for all causes over time by Kaplan-Meir analysis. These curves are not independent, meaning that all patients are represented in each curve for a particular failure mode.

Table I Cumulative risk of reoperation

Failure mode	No.*	1 y	2 y	5 y	10 y	15 y	20 y
		% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
All	208	2.6 (2.0-3.2)	3.4 (2.7-4.1)	5.2 (4.2-6.1)	11.2 (9.4-12.9)	16.8 (14.1-19.5)	20.2 (16.4-23.8)
Instability	89	2.0 (1.5-2.6)	2.6 (1.9-3.2)	3.2 (2.5-3.9)	4.4 (3.4-5.4)	5.1 (3.8-6.4)	5.7 (3.9-7.4)
Mechanical failure†	85	0.3 (0.1-0.6)	0.6 (0.2-0.8)	1.6 (1.0-2.2)	5.2 (3.8-6.5)	8.5 (6.3-10.6)	11.6 (8.1-15)
Rotator cuff tear	45	0.9 (0.5-1.2)	1.1 (0.7-1.6)	1.5 (1.0-2.0)	2.3 (1.5-3.1)	3.1 (2.0-4.2)	3.1 (2.0-4.2)
Infection	32	0.4 (0.2-0.6)	0.6 (0.3-0.9)	0.8 (0.5-1.2)	1.7 (1.0-2.5)	2.8 (1.5-4.1)	3.4 (1.7-5.1)
Periprosthetic fracture	17	0.14 (0-0.2)	0.1 (0-0.2)	0.2 (0-0.4)	1.3 (0.5-2.1)	1.8 (0.8-2.9)	2.6 (0.8-4.4)

95% CI, 95% confidence interval.

* The total is greater than 208 because some shoulders had more than 1 failure mechanism contribution to reoperation; for example, 35 shoulders had both rotator cuff tear and concurrent instability of the glenohumeral joint.

† Mechanical failure includes loosening, component fracture, and wear.

We used the actuarial method of calculating TSA survival to assess the cumulative risk of reoperation for each mode of failure at intervals (Table I). The risk of reoperation in the first year was higher than in any succeeding year (2.6%). Thereafter, the rates of reoperation generally decreased, reported annually (Table II). After the first year, there was no significant association between a specific time interval and the risk of reoperation ($P = .06$ by Poisson regression). When examining the most common modes of failure, we were unable to show any true "at-risk" period for reoperation in regards to a particular failure mechanism; instead, gradual linear trends were seen. Cumulative reoperations for mechanical failure gradually increased overtime, averaging 0.6% per year (Fig. 2). Reoperation for rotator cuff, instability, and infection were more likely to occur early, with 63% of these occurring in the first 2 years. Thereafter, a gradual decline in the rate of reoperations per year occurred for these mechanisms, averaging 0.4% per year.

Discussion

The demand for shoulder arthroplasty will continue to grow with our increasing population. In the era of cost-conscious

Table II Risk for reoperation by year

Interval start	Year	Failed	Censored	Person-years in the interval	Conditional probability of failure	Survival (95% CI)
(y)		(No.)	(No.)	(No.)	(%)	(%)
0	1	64	402	2418	2.60	97.4 (96.8-98.0)
1	2	19	99	2264	0.80	96.6 (95.9-97.3)
2	3	10	467	1881	0.50	96.1 (95.3-96.9)
3	4	13	100	1667	0.80	95.3 (94.4-96.2)
4	5	8	175	1519	0.50	94.8 (93.9-95.8)
5	6	19	411	1149	1.70	93.2 (92.1-94.4)
6	7	8	71	960	0.80	92.4 (91.2-93.7)
7	8	6	74	885	0.70	91.8 (90.5-93.2)
8	9	15	73	800	1.90	90.1 (88.5-91.7)
9	10	10	105	697	1.40	88.8 (87.1-90.6)
10	11	6	175	515	1.20	87.8 (85.9-89.8)
11	12	6	41	432	1.40	86.6 (84.5-88.8)
12	13	5	34	387	1.30	85.5 (83.3-87.9)
13	14	4	32	356	1.10	84.6 (82.2-87.1)
14	15	5	51	304	1.60	83.2 (80.5-85.9)
15	16	1	101	212	0.50	82.7 (80.0-85.6)
16	17	2	23	163	1.20	81.7 (78.7-84.9)
17	18	0	17	143	0.00	81.7 (78.7-84.9)
18	19	3	14	124	2.40	79.8 (76.2-83.6)
19	20	0	17	107	0.00	79.8 (76.2-83.6)
20	21	4	19	45	0.01	78.1 (73.8-82.5)

CI, confidence interval.

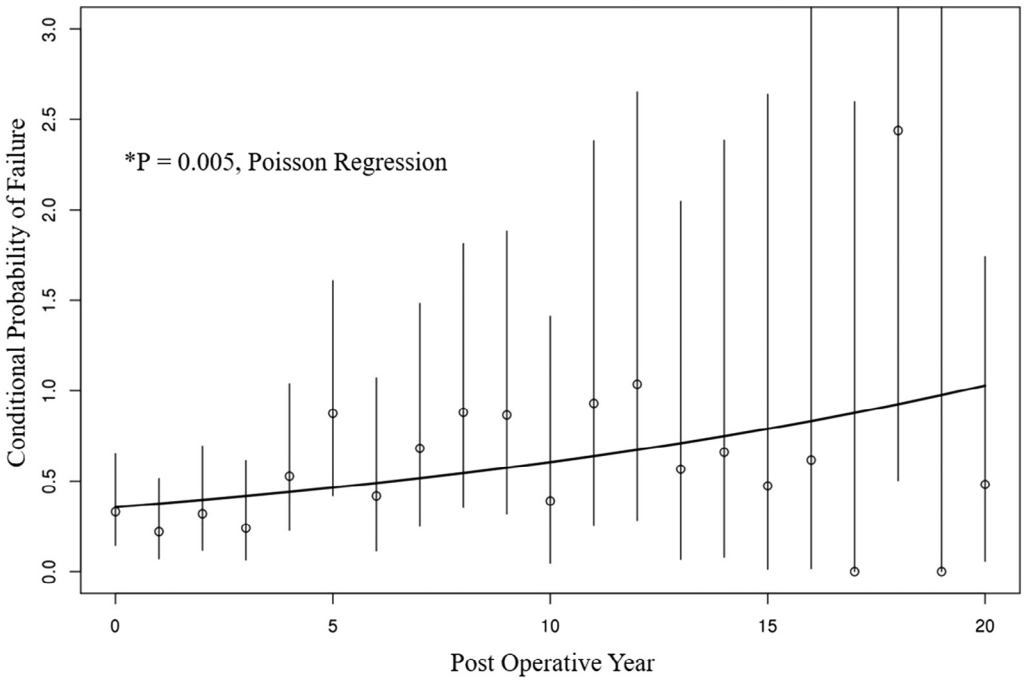

Figure 2 Graph with the best fit line for conditional probability of failure in regards to 1 year time intervals from surgery for mechanical failure. This includes aseptic component loosening, component wear, and implant fracture. The *vertical lines* represent the 95% confidence interval for each estimate.

medicine, surgeons must adapt to meet increasing demand while simultaneously minimizing costs to the health care system. Follow-up may represent the easiest and most surgeon-controlled mechanism by which to control direct health care costs. Changes in follow-up schedules have previously been proposed in the total knee arthroplasty literature[4]; however, no large-scale changes have been adopted. Whether this is secondary to reimbursement capture or patient/surgeon preference, or both, remains unclear.

Based on our institutional experience with anatomic TSA, we propose making changes to our own clinical follow-up schedule. Early failures resulting in reoperation were most commonly due to soft tissue failures (rotator cuff tears and instability) and infection. Of all reoperations within the first year, 76.6% were due to the early failure mechanisms identified in this study. Werner et al[8] showed a similar rate of reoperations at 1 year of 70.9% with these early modes of failure. After 2 years, the conditional probability for failure leading to reoperation was 1.1% per year for all mechanisms. With interventional action being required so infrequently, it is hard to justify the cost to the patient for an in-person evaluation by his or her physician. In addition, the low need for intervention and increased patient costs may explain some of the difficulties in convincing patients to return for follow-up when they are doing well.[1]

The strength of this study is that it represents a single institution's experience with shoulder arthroplasty over a long period, which allowed capturing of multiple failure modes over time. The main weakness of this study is that our only end point was reoperation, with the potential to miss worsening clinical outcomes or complications that did not lead to reoperation based on the patient's preference or the surgeon's recommendations. Patients with nonoperative complications that required closer follow-up (ie, periprosthetic fractures) were also not included. However, identifying these patients is not dissimilar to patients now who experience such complications before routinely scheduled follow-up in the current system.

In addition, implants and techniques have changed over time. High-failure implants were removed from analysis, but newer components, such as ingrowth glenoids, may fail at different time periods than cemented all-poly glenoids. There remains an important role for large registries to identify these failing designs earlier than can be identified by individual surgeons or research groups, especially if surgeons choose to reduce in-person follow-up.

We do not propose discharging patients from follow-up after this 2-year visit, but rather, monitoring these patients remotely without the requirements and financial costs of a formal outpatient visit. Initially, interval in-person follow-up should be scheduled for the first 2 years. In addition to our current follow-up schedule, wound rechecks at 2 weeks and 6-month clinical follow-up visits may also be appropriate. After 2 years, contact through mail/email with validated questionnaires and radiographs can be sent to the surgeon for review.[5,9] Patient scores can then be monitored over time to assess for changes in functional status that could then trigger an in-person evaluation. Further financial implications would include establishing a mechanism for reimbursement to surgeons for their review of outcomes and radiographs and selection of those patients who would need to return for management of complications. In our current practice, remote follow-up is requested every 5 years. However, it is important for surgeons to maintain contact with their patients and encourage them to contact the surgeon earlier if there are concerns for infection, increasing pain, or decreasing function in order to alter the planned follow-up schedule. More research is needed to determine the optimal timing of radiographic follow-up and what scoring trends should alert surgeons to patient-related issues.

Conclusion

TSA failure after 2 years is relatively uncommon and triggers surgical intervention in approximately 1% of patients per year. Routine in-person surveillance of all patients on a scheduled basis may not be necessary and would increase patient and other health care costs. We recommend in-person visits to assess healing, direct rehabilitation, and manage soft tissue or infectious issues until 2 years, with planned, periodic patient mail contact thereafter unless patient concerns arise or a newer implant design warrants closer clinical assessment.

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