Comparison of Survivorship & Failure Modes Between Anatomic and Reverse Total Shoulder Arthroplasty Across Multiple Government Joint Registries for a Single Platform Shoulder System

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Introduction: The safety and efficacy of shoulder arthroplasty is well-established in the orthopaedic literature as a successful treatment option for a variety of degenerative condition of the glenohumeral joint. Historically, anatomic total shoulder arthroplasty (aTSA) has been used to treat osteoarthritis (OA) and reverse total shoulder arthroplasty (rTSA) has been used to treat rotator cuff tear arthropathy (CTA) and OA in combination with rotator cuff tears. However, recent years has seen a dramatic shift in utilization towards rTSA. The reasons for this shift in usage are multi-factorial, but may be due to the perceived lower risk of revision surgery associated rTSA relative to aTSA, as the quality of the rotator cuff muscles and tendon are not necessary for a functional rTSA but are pre-requisite for a functional aTSA. To better understand the relative differences in primary aTSA and primary rTSA performance, we analyzed 2 different government joint registries for survivorship and failure modes associated with one platform shoulder system.

Methods: A review of the United Kingdom (UK) and Australian national joint registries was performed for a single shoulder prosthesis from 2011 to 2022 to investigate changes in annual usage of primary aTSA and primary rTSA relative to differences in survivorship and reasons for revision for each prosthesis type. Reasons for revision and the cumulative revision rate were assessed across the government joint registries to quantify and compare the performance of this platform shoulder prosthesis for primary aTSA and primary rTSA applications.

Results: Between June 2011 and July 2022, 633 primary aTSA (95.6% OA; 312M/321F) and 4,048 primary rTSA (51.5% OA & 35.4% CTA; 1723M/2325F) were performed in Australia by 168 surgeons in 151 different hospitals and between April 2012 and June 2022, 1,371 primary aTSA (92.2% OA; 454M/917F) and 3,659 primary rTSA (42.5% OA & 50.4% CTA; 1,014M/2,645F) were performed in the UK by 180 surgeons in 145 different hospitals using the same platform shoulder prosthesis. From 2011 to 2022, the overall incidence of aTSA and rTSA revisions was low, where specifically 99 of 2,004 primary aTSA (4.9%) patients and 216 of 7,707 primary rTSA (2.8%) patients with this specific platform shoulder prosthesis were revised. However, as described in Figure 1, the average 8-year cumulative revision rate for primary aTSA patients was higher than that for primary rTSA patients, where 7.7% of aTSA patients were revised at 8 years (0.96% revised/year) but only 4.4% of primary rTSA patients were revised at 8 years (0.55% revised/year). The trend for more revisions with aTSA than rTSA was observed in both the UK and Australian registries when all shoulder devices were considered, not just the single platform shoulder system analyzed in this study. No difference in hazard ratios for revision were observed for the Equinoxe aTSA as compared to all other aTSA systems in the Australian (hazard ratio = 1.16, p=0.332) or UK (hazard ratio = 1.16, p=0.311) registries. Similarly, no difference in hazard ratio was observed for the Equinoxe rTSA as compared to all other rTSA systems in the Australian (hazard ratio = 0.91, p=0.302) or UK (hazard ratio = 1.00, p=0.990) registries.

The reason for aTSA and rTSA revision are presented in Figures 2 and 3, respectively. The two most common reasons for aTSA revision across the Australia and UK registries combined were both soft-tissue related and accounted for 56.5% of all aTSA revisions (56 of 99: rotator cuff tear/failure (n=34, 1.7%) + instability/dislocations (n=22, 1.1%). The next most common reason for aTSA revision was aseptic glenoid loosening, which occurred in 14 of 99 aTSA revisions and accounted for 14.1% of all aTSA revisions. After that, the next most common reason for aTSA revision was infection, which occurred in 8 of 99 aTSA revisions and accounted for 8.1% of all aTSA revisions. Comparing rates of each reason for revision relative to all other aTSA prostheses in the Australian registry limited to the same max follow-up demonstrated that the Equinoxe aTSA had a significantly lower overall revision rate relative to other aTSA prosthesis (4.9% vs. 8.8%, p<0.0001) and a significantly lower revision rate for the reasons of rotator cuff failure (1.7% vs 2.3%, p<0.0001), instability/dislocation (1.1% vs. 2.0%, p=0.0061), loosening (0.7% vs. 1.6%, p=0.0015), implant fracture (0.1% vs 0.8%, p=0.0012), and implant disassociation (0% vs 0.4%,p=0.0059). Notably, 0 revision cases out of 2,004 aTSA patients were reported due to lysis and/or polyethylene wear. By comparison for aTSA, the most common reason for revision was infection, which occurred in 85 of 216 rTSA revisions and accounted for 39.4% of all rTSA revisions. The next most common reason for rTSA revision was instability/dislocation, which occurred in 57 of 216 aTSA revisions and accounted for 26.4% of all rTSA revisions. After that, the next most common reason for rTSA revision was loosening, which occurred in 25 of 216 rTSA revisions and accounted for 11.6% of all rTSA revisions. Comparing rates of each reason for revision relative to all other rTSA prostheses in the Australian registry limited to the same max follow-up demonstrated that the Equinoxe rTSA had a significantly lower overall revision rate relative to other rTSA prosthesis (2.8% vs. 3.8%, p<0.0001) and a significantly lower revision rate for the reasons of instability/dislocation (0.7% vs. 1.2%, p=0.0002), loosening (0.3% vs. 0.6%, p=0.0015), implant disassociation (0% vs 0.1%, p=0.0162), pain (0% vs 0.1%,p=0.0110), and polyethylene wear/lysis (0% vs. 0.1%, p=0.0167). Notably, 0 revision cases out of 7,707 rTSA patients were reported due to lysis and/or polyethylene wear.

Discussion: The results of this large-scale, 10-year multi-country registry analysis of 9,711 primary shoulder arthroplasty patients with the same platform system yielded several important findings. Most significantly, the 8-year cumulative revision rate associated with this platform shoulder system is low for both primary aTSA and primary rTSA patients. However, we did observe a difference in revision rate between prosthesis types, where specifically, the 8-year cumulative revision rate with primary rTSA was about half the 8-year cumulative revision rate of primary aTSA. The analysis of reasons for aTSA and rTSA revision yielded several interesting findings which may explain the changes in utilization toward rTSA. The most notable difference in the reasons for revision between primary aTSA and primary rTSA patients was that rTSA patients experienced only 1 case of revision due to rotator cuff tears/subscapularis failure as compared to the 34 cases of rotator cuff tears/subscapularis failure with aTSA which accounted for >1/3 of all aTSA revisions. Furthermore, soft-tissue related failure modes (e.g. rotator cuff tears/subscapularis failure and instability/dislocation) were the most common reasons for aTSA failure and were responsible for 56.5% of all aTSA revisions since 2011 in Australia and the UK; in contrast, soft-tissue related failure modes were responsible for only 26.9% of all rTSA revisions. These differences in failure rates are likely due to inherent differences in biomechanics between prosthesis types. It is also interesting to note that >10-years of use for 9,711 shoulders resulted in 0 cases of revision due to lysis and/or polyethylene wear. These results suggest that the predominate shoulder failure modes are different than that of hip and knee arthroplasty, likely due to the shoulder being associated with substantially lower magnitudes of peak loads and also a reduced frequency of peak loads relative to weight bearing joints.

This study has several limitations. First, our registry analysis only permitted a comparison of revision rates between 2 prosthesis types of the same shoulder system, reasons for revision are almost always multi-factorial and those details may not be considered when analyzed in aggregate. Second, while the relative risk of revision is an important consideration of prosthesis performance, it does not completely describe a patient's clinical outcome. Future work is required to compare differences in functional outcomes, range of motion, pain, and patient reported outcome measures between aTSA and rTSA. Finally, case-specific information related to surgical technique and implant position is limited, however, 4 cases of aTSA revision and 3 cases of rTSA revision were implied to be surgeon-induced (i.e. "incorrect size" and "malpositioning"), these findings highlight the need for continued medical education and improvements in surgical technique and instrumentation usability to ensure successful and reliable outcomes are achieved for all users regardless of experience level or learning curve.

Significance: In conclusion, this comparative analysis of failure modes and survivorship demonstrate low rates of failure for both aTSA and rTSA with one specific platform shoulder prosthesis, but also identified that rTSA patients had a lower revision rate and where not susceptible to the most common failure mode of aTSA: rotator cuff tears/subscapularis failure, potentially explaining the reason why so many more primary patients are now being treated with rTSA.

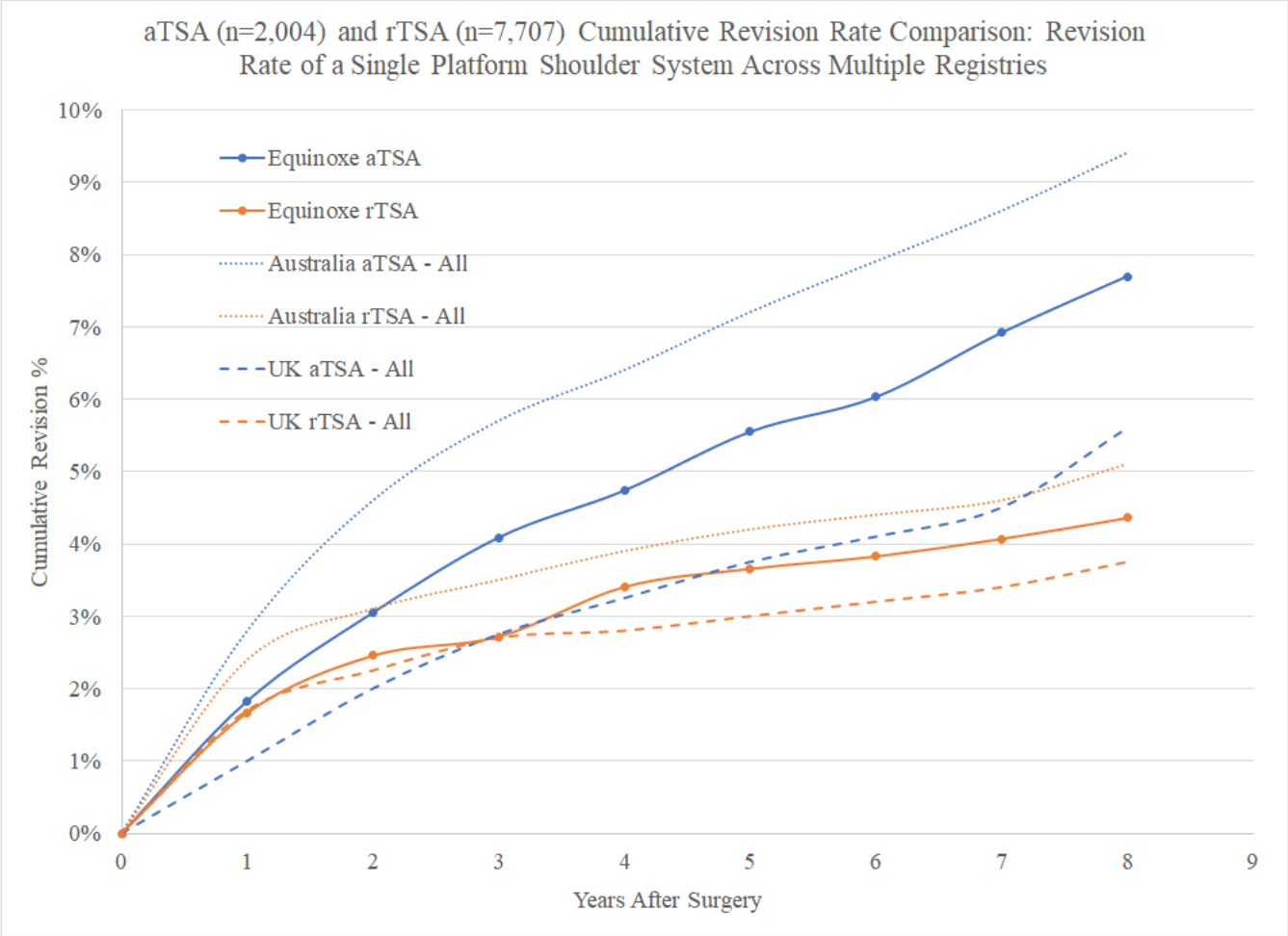

Figure 1. Combined UK and Australian National Joint Registry Comparison of Cumulative Revision Rate from 2011-2022 for a Single Platform Shoulder Prosthesis: Primary aTSA (n=2,004) vs. Primary rTSA (n=7,707)

Equinoxe aTSA Reasons for Revision	Patient, Device, or Technique Related Failure Mode	Equinoxe aTSA in the Australian Registry (#,%) N = 633	Equinoxe aTSA in the UK Registry (#,%) N = 1371	Equinoxe aTSA Combined Australia and UK Registry Reasons for Revision (#,%) N = 2,004	% of Total Number of Revisions for Equinoxe aTSA in Combined Australia & UK Registry N = 99	Expected Revision % as Reported in the Australian Registry for all other aTSA Prostheses	P Value (Combined Registry Equinoxe Revision Rate vs Revision Rate of All Other aTSA in Australia Registry)
Rotator Cuff Failure	Patient	10 (1.6%)	24 (1.8%)	34 (1.7%)	34.3%	341 (2.3%)	**<0.0001**
Instability/dislocation	Patient	9 (1.4%)	13 (0.9%)	22 (1.1%)	22.2%	300 (2.0%)	**0.0061**
Loosening	Device	12 (1.9%)	2 (0.1%)	14 (0.7%)	14.1%	245 (1.6%)	**0.0015**
Infection	Patient***	4 (0.6%)	4 (0.3%)	8 (0.4%)	8.1%	96 (0.6%)	0.2019
Implant Fracture	Device	3 (0.5%)	0 (0%)	3 (0.1%)	3.0%	122 (0.8%)	**0.0012**
Implant Disassociation	Device	0 (0%)	0 (0%)	0 (0%)	0%	57 (0.4%)	**0.0059**
Pain	Patient	1 (0.2%)	0 (0%)	1 (0%)	1.0%	28 (0.2%)	0.1664
Incorrect size	Technique	3 (0.5%)	0 (0%)	3 (0.1%)	3.0%	16 (0.1%)	0.5793
Malposition	Technique	1 (0.2%)	0 (0%)	1 (0%)	1.0%	11 (0.1%)	0.7164
Lysis/Poly Wear	Device	0 (0%)	0 (0%)	0 (0%)	0%	27 (0.2%)	0.0583
Arthrofibrosis	Patient	2 (0.3%)	0 (0%)	2 (0.1%)	2.0%	18 (0.1%)	0.8126
Humeral fracture	Patient	2 (0.3%)	1 (0.1%)	3 (0.1%)	3.0%	35 (0.2%)	0.4648
Metal Related Pathology	Patient	0 (0%)	0 (0%)	0 (0%)	0%	19 (0.1%)	0.7778
Other**	Unknown	0 (0%)	12 (0.9%)	12 (0.6%)	12.1%**	16 (0.1%)	**<0.0001****
Total # of Revisions	All	47	52	99	103.8%*	1331	NA
Total # of Patient Related Revisions	Patient	28	42	70	70.7%	62.9%	0.1192
Total # of Device Related Revisions	Device	15	2	17	17.2%	33.9%	**0.0006**
Total Number of Technique Related Revisions	Technique	4	0	4	4.0%	2.0%	0.1851
All Cause Revision Rate	All	7.4%	3.8%	4.9%	4.9%	8.8%	**<0.0001**

*Note that this is >100% because some patients have more than 1 reason for revision cited.

**Note that the UK registry tends to include more "other" reasons for revision than the Australian registry, so this difference is a consequence of the combined analysis.

***Note that this failure mode could also be classified as a technique related failure mode, since it is an inherent risk of the surgical operation, we decided to classify it as only a patient related failure mode to not double count.

Figure 2. Primary aTSA Reasons for Revision Across the UK and Australian National Joint Registries for a Single Platform Shoulder Prosthesis as Compared to Reasons for Revision for all other aTSA Shoulder Prostheses in the Australian National Joint Registry with the Same Maximum Follow-up

Equinoxe rTSA Reasons for Revision	Patient, Device, or Technique Related Failure Mode	Equinoxe rTSA in the Australian Registry (#,%) N = 4,048	Equinoxe rTSA in the UK Registry (#,%) N = 3,659	Equinoxe rTSA Combined Registry Reasons for Revision (#,%) N = 7,707	% of Total Number of Revisions for Equinoxe rTSA in Combined Australia & UK Registry N = 216	Expected Revision % as Reported in the Australian Registry for all other rTSA Prostheses	P Value (Combined Registry Equinoxe Revision Rate vs Revision Rate of All Other rTSA in Australia Registry)
Rotator Cuff Failure	Patient	1 (0%)	0 (0%)	1 (0%)	0.5%	5 (0%)	0.9418
Instability/dislocation	Patient	33 (0.8%)	24 (0.7%)	57 (0.7%)	26.4%	519 (1.2%)	**0.0002**
Loosening	Device	21 (0.5%)	4 (0.1%)	25 (0.3%)	11.6%	260 (0.6%)	**0.0015**
Infection	Patient***	43 (1.1%)	42 (1.1%)	85 (1.1%)	39.4%	372 (0.9%)	0.0744
Implant Fracture	Device	0 (0%)	0 (0%)	0 (0%)	0%	15 (0%)	0.0960
Implant Disassociation	Device	3 (0.1%)	0 (0%)	3 (0%)	1.4%	61 (0.1%)	**0.0162**
Pain	Patient	0 (0%)	0 (0%)	0 (0%)	0%	35 (0.1%)	**0.0110**
Incorrect size	Technique	1 (0%)	0 (0%)	1 (0%)	0.5%	10 (0%)	0.5525
Malposition	Technique	2 (0%)	0 (0%)	2 (0%)	0.9%	18 (0%)	0.4909
Lysis/Poly Wear	Device	0 (0%)	0 (0%)	0 (0%)	0%	31 (0.1%)	**0.0167**
Arthrofibrosis	Patient	0 (0%)	0 (0%)	0 (0%)	0%	20 (0%)	0.0546
Humeral fracture	Patient	14 (0.3%)	7 (0.2%)	21 (0.3%)	9.7%	177 (0.4%)	0.0529
Metal Related Pathology	Patient	1 (0%)	0 (0%)	1 (0%)	0.5%	9 (0%)	0.6262
Other**	Unknown	4 (0.1%)	21 (0.6%)	25 (0.3%)	11.6%**	44 (0.1%)	**<0.0001****
Total # of Revisions	All	123	93	216	102.5%*	1578	NA
Total # of Patient Related Revisions	Patient	91	73	164	75.9%	72.1%	0.2320
Total # of Device Related Revisions	Device	24	4	28	13.0%	23.3%	**0.0006**
Total Number of Technique Related Revisions	Technique	3	0	3	1.4%	1.8%	0.6836
All Cause Revision Rate	All	3.0%	2.5%	2.8%	2.8%	3.8%	**<0.0001**

*Note that this is >100% because some patients have more than 1 reason for revision cited.

**Note that the UK registry tends to include more "other" reasons for revision than the Australian registry, so this difference is a consequence of the combined analysis.

***Note that this failure mode could also be classified as a technique related failure mode, since it is an inherent risk of the surgical operation, we decided to classify it as only a patient related failure mode to not double count.

Figure 3. Primary rTSA Reasons for Revision Across the UK and Australian National Joint Registries for a Single Platform Shoulder Prosthesis as Compared to Reasons for Revision for all other aTSA Shoulder Prostheses in the Australian National Joint Registry with the Same Maximum Follow-up