Results of Anatomic Total Shoulder Arthroplasty with Modern Metal-Backed Glenoid

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Introduction

Total shoulder arthroplasty is an effective treatment option for certain patients with glenohumeral arthritis that fail non-operative treatments. Glenoid component failure is a known sequela of shoulder arthroplasty and is one of the most common prosthesis-specific causes for revision.[1] Metal-backed designs were developed to address the limitations of the all-polyethylene glenoid component. By allowing for tissue ingrowth on the porous trabecular surface of the component, it was believed that metal-backed implants could address the problems with loosening seen with cemented all-polyethylene glenoid components.[7]

Initially the experience with metal-backed glenoid components was not favourable, with high rates of loosening requiring revision or conversion procedures.[2] Much of the initial experience could be explained by variations in technique, the technical learning curve of the procedure and limitations to the implant design. More recent literature has suggested that the modern metal-backed glenoid has lower rates of radiolucency, loosening and revision surgery compared to conventional designs.[3,7]

The purpose of this study is to demonstrate that a modern-design metal-backed implant can achieve similar survivorship to historical controls. We hypothesise that there is a learning curve to mastering the technique and that after mastery is achieved, equivalent outcomes can be achieved with a metal-backed design.

Methods

Patient Population:

A retrospective chart review was performed of all patients who underwent total shoulder arthroplasty by a single surgeon between January 1, 2014 and December 31, 2019. Charts were queried based on the CPT code 23472, which represents "total arthroplasty of glenohumeral joint with glenoid and proximal humeral replacement".

Patients that underwent an anatomic total shoulder arthroplasty with a metal-backed glenoid component and had minimum six months of follow-up were included in the analysis. Patients who underwent hemiarthroplasty or reverse total shoulder arthroplasty, revision shoulder arthroplasty, had less than six months of follow-up or underwent an anatomic total shoulder arthroplasty with an all-polyethylene glenoid component were excluded from the analysis.

Demographic information including age, gender, race, ethnicity, BMI, smoking status, and preexisting health conditions was recorded. For each patient implant data was collected as well including size of the glenoid component (small, standard or large), as well as size (mm) and eccentricity (mm) of the humeral head.

Patient charts were evaluated for complications and revision procedures. For complications, the type of complication was recorded. For revision procedures, the time from the index procedure, reason for revision and type of revision was recorded.

Patients were separated into the first forty (Cohort A) and second forty (Cohort B) patients. Patients were separated in this fashion to evaluate for differences in complication and revision rates based on the technical learning curve of the procedure.

Descriptive statistics of the patient cohorts were analysed and reported. Univariate analysis, chi-square test, and multivariate logistic regression were used to compare each patient cohort. Statistical significance was set at $P < .05$, and statistical analyses were performed using SAS software, version 9.4 (SAS Institute, Cary, North Carolina).

Results

A total of eighty patients met criteria for the study. Except for differences in rates of connective tissue diseases (eg. SLE, rheumatoid arthritis) and gender, there were no significant differences in demographics between groups. There were 24 (60%) and 15 (37.5%) males in Cohorts A and B respectively ($p = 0.0441$). The average age within the two cohorts was 58.8 and 59.6 years respectively. Average BMI within the two groups was 31 and 33 respectively (Table 1).

There was a significant difference in the revision rate ($p = 0.0052$) between the two cohorts (Table 2). For Cohort A there were 13

Table 1. Demographic Data

	Cohort A	Cohort B	P-value
Age (y)	58.8	59.6	0.6421
Female, No. (%)	24 (40%)	15 (37.5%)	0.0441
BMI	31	33	0.5297
Smoker, No. (%)	7 (17.5%)	8 (20%)	0.5923
Myocardial Infarction, No. (%)	2 (5%)	3 (7.5%)	0.6293
Congestive Heart Failure, No. (%)	3 (7.5%)	4 (10%)	0.6923
Peripheral Vascular Disease, No. (%)	6 (15%	2 (5%)	0.0769
Cerebrovascular Accident, No. (%)	2 (5%)	3 (7.5%)	0.6293
Dementia, No. (%)	0 (0%)	0 (0%)	
COPD, No. (%)	8 (20%)	5 (12.5)	0.1521
Connective Tissue Disease, No. (%)	8 (20%)	0 (0%)	0.0029
Peptic Ulcer Disease, No. (%)	3 (7.5%)	0 (0%)	0.0775
Liver Disease, No. (%)	5 (12.5)	4 (10%)	0.7235
Diabetes, No. (%)	4 (10%)	10 (25%)	0.0775
Leukemia/Lymphoma, No. (%)	0 (0%)	0 (0%)	
HIV/AIDS, No. (%)	0 (0%)	3 (7.5%)	0.0775
Chronic Kidney Disease (Mod - Severe), No. (%)	6 (15%	2 (5%)	0.136

Table 2. Revision Rates of Cohorts A & B

	Cohort A	Cohort B	P-value
Revision Rate No. (%)	13 (16.25)	3 (3.75)	0.0052
Months to Revision from index procedure Mean (Range)	17.8 (1-43)	12.7 (8-19)	

revisions that took place at an average 17 months (range: 1 to 43 months) from the index procedure. The causes for revisions included rotator cuff tearing (n = 4), shoulder instability (n = 3), shoulder pain and/or dysfunction (n = 3), subscapularis tear (n = 2) and stiffness (n = 1). Eleven patients underwent revision total shoulder arthroplasty, while one patient underwent subscapularis repair and another underwent revision of the humeral component. The patient that underwent revision of the humeral component went on to undergo conversion to reverse total shoulder arthroplasty five months later.

For Cohort B there were 3 revisions that took place at an average 12.7 months (range: 8 to 19 months) from the index procedure. The causes for revision included rotator cuff tear (n = 1), adhesive capsulitis (n = 1), and posterior shoulder instability (n = 1). All patients underwent conversion to a reverse total shoulder arthroplasty.

There was no significant difference in complication rates (p = 0.2371) between groups. Within Cohort A there were 16 subjects who experienced complications, whereas in Cohort B there were 11 subjects who experienced complications. Within Cohort A complications included rotator cuff tears or insufficiency (n = 5), adhesive capsulitis (n = 4), and subscapularis tears (n = 2). There were ± patients who underwent procedures post-operatively including arthroscopic lysis of adhesions and/or capsular release (n = 3), manipulation under anesthesia (n = 1), and arthroscopic debridement (n = 2). Within Cohort B complications included rotator cuff tears (n = 3), adhesive capsulitis (n = 2). There was one death and one patient who developed a C. acnes prosthetic joint infection that was treated with arthroscopic debridement six months post-operatively.

There was no significant difference in component sizes between groups (Tables 3 & 4). Specifically, there was no difference in humeral head size (p-value .2601), humeral head eccentricity (p-value 0.3871), or glenoid size (p-value 0.7918). There were no significant differences in component sizes between those patients that required revision and those that did not (p-values 0.7914, 0.9842, and 0.6954 for humeral head size, humeral head eccentricity and glenoid size respectively) (Tables 5 & 6).

Discussion

The most notable finding of this study was that the revision rate for the first 40 patients was more than four times greater than that of the second 40 patients (p = 0.0052). A previous study by Kempton et al. observed a learning curve of 40 cases

Table 3. Glenoid Component Sizes of Groups A & B

	Cohort A	Cohort B	P-value
			0.7918
Large No. (%)	7 (8.75)	9 (11.25)	
Standard No. (%)	20 (25.00)	20 (25.00)	
Small No. (%)	13 (16.25)	11 (13.75)	

Table 4: Humeral Component Size of Cohorts A & B

	Cohort A	Cohort B	P-value
Humeral Head Size (mm)	47.65	47.9	0.6552
Humeral Head Eccentricity (mm)	3.175	2.6	0.4932

Table 5. Glenoid Component Sizes of Revision and Non-Revision Groups

	Revision Surgery number (%)	No Revision Surgery number (%)	P-value
			0.6954
Large, No. (%)	2 (12.50)	14 (21.87)	
Standard, No. (%)	9 (56.25)	31 (48.43)	
Small, No. (%)	5 (31.25)	19 (29.68)	

Table 6: Humeral Component Size of Revision and Non-Revision Groups

	Revision	Non-Revision	P-value
Humeral Head Size (mm)	47.75	47.78	0.7914
Humeral Head Eccentricity (mm)	2.79	2.89	0.9842

for surgeons performing reverse total shoulder arthroplasty.[6] The results of this study would suggest that there is a learning curve to performing anatomic TSA with a metal-backed implant and that the threshold for obtaining more predictable results with the implant occurs after the first 40 surgeries.

Historical studies have demonstrated worse outcomes amongst cohorts of patients undergoing anatomic total shoulder arthroplasty with metal-backed glenoid implants. Boileau et al. demonstrated inferior results of metal-backed implants compared to all-cement polyethylene components at a minimum of three years in their prospective, randomised trial, with a 20% incidence of loosening and 20% incidence of revision surgery amongst 20 patients randomised to a metal-backed implant.[2] A more recent systematic review performed by Papadonikolakis and Matsen demonstrated revision rates for anatomic TSA with metal-backed glenoid components three times that of all-polyethylene components. (Papadonikolakis et al., 2014) In their study 77% of revisions for all-polyethylene components were performed for loosening while 62% of revisions in the metal-backed group were performed for other reasons such as rotator cuff tear, component fracture, screw breakage, or component dissociation.

More recently, a systematic review comparing modern metal-backed glenoid designs with conventional designs observed significantly lower revision rates with modern designs. (Kim et al., 2020) One of the modern designs described in the Kim et al. study was that designed by LimaCorporate, a design utilised by the senior author for the patients included in this study. Features of the prosthesis that may make it superior to traditional metal back glenoids include its stiff, thick metal back designed to minimise wear, hydroxyapatite coating on the central peg and stable fixation through 2 screws and a central peg.

To the best of our knowledge there are no studies that have assessed revision and cation rates based on size of glenoid and humeral components for anatomic total shoulder arthroplasty. It has been suggested that because the metal-backed glenoid tends to be thicker, the articular surface may be lateralized, which could potentially increase the risk of rotator cuff or subscapularis failure (Katz et al., 2013). In our study there was no difference in revision rates based on component size nor was there any difference in component size between the two cohorts.

One of the most common modes of failure observed amongst patients in this study was rotator cuff tearing or insufficiency, making up 31.25% of all reasons for revision. In a systematic review by Papadonikolakis and Matsen, cuff failure was the reason for revision in only 4% of 200 subjects who underwent TSA with a metal-backed glenoid.[9] The results of this study were closer to that of the systematic review of Kim et al., wherein rotator cuff failure was the reason for revision in 21.4% of patients that required revision after TSA with a modern design metal-backed glenoid.[7]

There are several limitations of this study related to its retrospective nature, the lack of long-term follow-up data, and the small patient numbers. Future studies would include radiographic data on implant loosening and patient outcomes scores. This study adds to the current body of literature by confirming that lower revision rates can be achieved with a modern-design metal-backed glenoid implant after completing enough cases to achieve mastery.

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