Research Article

Osteoporosis and Implant-Related Complications After Anatomic and Reverse Total Shoulder Arthroplasty

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Abstract

Introduction: Osteoporosis is a widespread and growing medical condition, with significant orthopaedic implications. However, the effect of osteoporosis on outcomes after total shoulder arthroplasty (TSA) is not well understood. The goal of the present study was to characterize the incidence of osteoporosis in patients undergoing shoulder arthroplasty and to examine whether patients with osteoporosis undergoing anatomic and reverse TSA are at an increased risk of prosthetic-related complications.

Methods: Complication rates were calculated for patients with osteoporosis who underwent anatomic and reverse TSA as separate cohorts within 2 years of surgery including loosening/osteolysis, periprosthetic fracture, periprosthetic dislocation, and revision shoulder arthroplasty and compared using a multivariable logistic regression analysis to control for patient demographics and comorbidities during comparisons, including the indication for reverse TSA.

Results: The prevalence of an osteoporosis diagnosis at the time of surgery was 14.3% for anatomic TSA patients and 26.2% of reverse TSA patients. Anatomic TSA patients with osteoporosis experienced significantly higher rates of periprosthetic fracture (odds ratio [OR], 1.49; $P = 0.017$) and revision shoulder arthroplasty (OR, 1.21; $P = 0.009$) within 2 years of surgery compared with matched controls without osteoporosis. Patients in the reverse TSA group with osteoporosis also had significantly higher rates of periprosthetic fracture (OR, 1.86; $P = 0.001$) and revision shoulder arthroplasty (OR, 1.42; $P = 0.005$) within 2 years of surgery compared with matched controls.

Discussion: A significant number of patients undergoing both anatomic and reverse TSA have a concurrent diagnosis of osteoporosis. Osteoporosis represents a significant independent risk factor for periprosthetic fracture and revision shoulder arthroplasty within 2 years of surgery, regardless of the type of implant. Patients with osteoporosis should be counseled on their increased risk of complications after shoulder arthroplasty.

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Osteoporosis is a common condition characterized by low bone mineral density (BMD) that affects millions of Americans and continues to be a growing public health concern.[1,2] There are significant health and economic burdens associated with the complications from osteoporotic fractures, which have been well reported.[2-6] The effects of this disease process are far-reaching because it has been estimated that 50% of women and 20% of men aged 50 years and older will sustain an osteoporotic fracture in their lifetime, and the number of osteoporotic hip fractures continues to increase at an alarming rate.[5,7] As the population ages, total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RSA) are being performed on patients with osteoporosis, especially as shoulder arthroplasty is becoming a more common procedure for comminuted proximal humerus fractures in the elderly.[8-10] The effect that this disease process has on outcomes has not been completely studied for these procedures.

Although osteoporosis is closely linked to implant failure and fragility fractures in orthopaedic literature,[11-13] the literature evaluating its effects on the outcomes of shoulder arthroplasty is limited. The purpose of the present study is to use a national database to evaluate and compare complications after TSA and reverse shoulder arthroplasty in patients with osteoporosis and to compare complication rates to those patients with and without osteoporosis. Our hypothesis is that a diagnosis of osteoporosis will confer an increased risk of prosthetic-related complications.

Methods

Data Source

The PearlDiver Patient Records Database (http://www.pearldiverinc.com, Fort Wayne, IN), a national for-fee insurance claim database of patient records, was used for this study. The database contains patients from both private insurers and the Medicare 100% standard analytical files. Available data include procedural volumes, patient demographics, concomitant diagnoses, and vast amounts of other data for patients with *International Classification of Diseases, Ninth Revision* (*ICD-9*) diagnoses and procedures or current procedural terminology codes. The data are organized in a trackable but anonymous fashion, and this study was therefore exempt from the authors' institutional review board. The 100% Medicare data sets (years 2005 to 2014) were used for the present study as osteoporosis is present in a much higher percentage of elderly patients, and there is a much larger number of shoulder arthroplasty procedures. Approximately 50 million patients are present in the 100% Medicare files at the time of this study.

Study Groups

Patients who underwent both anatomic (*ICD-9* procedure code 81.80) and reverse shoulder arthroplasty (*ICD-9* procedure code 81.88) during the database years of 2005 to 2014 were included. The TSA and RSA patients were treated as separate study cohorts for the entirety of the study. For the TSA group, only patients with TSA performed for a diagnosis of shoulder osteoarthritis (*ICD-9* codes 715.11, 715.21, 715.31, and 715.91). Because of lower available patient numbers, RSA for any diagnoses was included; however, the diagnosis at the time of surgery was later controlled for in the statistical analysis. In addition, only patients with a minimum of 2 years of database follow-up were included. Patients with a history of periprosthetic infection or a history of previous shoulder arthroplasty including hemiarthroplasty were excluded.

The study group of interest was patients who underwent TSA or RSA with a previous diagnosis of osteoporosis. These patients were identified by taking the patients who met the aforementioned inclusion and exclusion criteria and querying for a diagnosis of osteoporosis before the date of their surgery using the following *ICD-9* diagnostic codes: 733.0, 733.00, 733.01, 733.02, 733.03, and 733.09. The diagnosis of osteoporosis is included within the database when the patient is given this diagnosis by any practitioner, and it is recorded into their medical record.

Controls

Potential control patients were identified using the same inclusion and exclusion criteria as the study groups, but patients without a preoperative

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vor postoperative diagnosis of osteoporosis. These potential control patients were then matched in a 1:1 fashion by age and sex to the study patients. There were insufficient available control patients to match any more than 1:1. TSA and RSA patients were again treated as separate control groups and matched separately to their respective study groups.

Outcomes

The primary outcomes of interest for the study were prosthesis-related complications within 2 years postoperatively. These included loosening/osteolysis (*ICD-9* codes 996.41 and 996.45), periprosthetic fracture (*ICD-9* code 996.44), periprosthetic dislocation (*ICD-9* code 996.42), and revision shoulder arthroplasty (*ICD-9* procedure code 81.97). These complication rates were calculated for both the osteoporosis study groups and the matched control groups.

Demographics

The complete list of demographics and comorbidities for the TSA patients and matched controls is provided in Table 1. Similarly, demographics and comorbidities for the RSA study and control groups are provided in Table 2.

Table 1

Total Shoulder Arthroplasty: Patient Demographics

	Osteoporosis Group (n = 17,078)		Matched Control Group (n = 17,078)	
Variable	**n**	**%**	**n**	**%**
Demographics				
Age group (yr)				
Less than 65	1,149	6.7	1,149	6.7
65-69	2,334	13.7	2,334	13.7
70-74	4,135	24.2	4,135	24.2
75-79	4,638	27.2	4,638	27.2
80-84	3,378	19.8	3,378	19.8
85+	1,444	8.5	1,444	8.5
Sex (female)	15,255	89.3	15,255	89.3
Obesity (BMI 30-39.9 kg/m^2)	3,074	18.0	3,193	18.7
Morbid obesity (BMI 40+ kg/m^2)	2,081	12.2	2,233	13.1
Tobacco use	2,336	13.7	2,336	13.7
Alcohol abuse	574	3.4	497	2.9
Comorbidities				
Diabetes mellitus	6,209	36.4	6,209	36.4
Hyperlipidemia	14,607	85.5	13,573	79.5
Hypertension	15,768	92.3	15,517	90.9
Peripheral vascular disease	2,941	17.2	2,352	13.8
Congestive heart failure	4,940	28.9	4,472	26.2
Coronary artery disease	7,328	42.9	6,670	39.1
Chronic kidney disease	4,017	23.5	3,709	21.7
Chronic lung disease	5,170	30.3	4,824	28.2
Chronic liver disease	1,140	6.7	884	5.2
Thyroid disease	7,871	46.1	6,797	39.8
Depression	6,428	37.6	6,069	35.5

BMI = body mass index

Statistical Analysis

Demographics and comorbidities were reported as output by the database. Comparisons of complication rates between the patients with osteoporosis and age- and sex-matched control groups were performed using a multivariate logistic regression analysis to control for patient demographics and comorbidities during comparisons. In addition, for RSA, the diagnosis at the time of surgery (ie, osteoarthritis, rotator cuff tear, or proximal humerus fracture) was included in the regression and controlled for as well. Odds ratios (ORs) were calculated with respective 95% confidence intervals (CIs). $P < 0.05$ was considered statistically significant for all comparisons.

Results

A total of 68,730 patients were included in the study, including 17,078 patients with osteoporosis who underwent anatomic TSA and 17,287 patients who underwent RSA and the respective 1:1 matched controls for both the anatomic TSA and RSA patients. The database incidence of osteoporosis was calculated based on all patients who underwent shoulder arthroplasty within the database. Osteoporosis was listed as a diagnosis before the time of surgery in 14.3% of all anatomic TSA patients, whereas it was present in 26.2% of the patients who underwent RSA.

Patients with a diagnosis of osteoporosis who underwent anatomic TSA had significantly higher rates of periprosthetic fracture (OR, 1.49; 95% CI, 1.08 to 2.07; $P = 0.017$) and revision shoulder arthroplasty (OR, 1.21; 95% CI, 1.09 to 1.34; $P = 0.009$) within 2 years postoperatively compared with matched controls without osteoporosis

Table 2

Reverse Total Shoulder Arthroplasty: Patient Demographics

Variable	Osteoporosis Group (n = 17,287) n	%	Matched Control Group (n = 17,287) n	%
Demographics				
Age group (yr)				
Less than 65	861	5.0	861	5.0
65-69	1,878	10.9	1,878	10.9
70-74	3,690	21.3	3,690	21.3
75-79	4,599	26.6	4,599	26.6
80-84	3,850	22.3	3,850	22.3
85+	2,409	13.9	2,409	13.9
Sex (female)	15,661	90.6	15,661	90.6
Obesity (BMI 30-39.9 kg/m^2)	3,060	17.7	3,359	19.4
Morbid obesity (BMI 40+ kg/m^2)	1,972	11.4	2,282	13.2
Tobacco use	2,807	16.2	2,807	16.2
Alcohol abuse	730	4.2	563	3.3
Comorbidities				
Diabetes mellitus	6,470	37.4	6,470	37.4
Hyperlipidemia	14,856	85.9	13,917	80.5
Hypertension	16,009	92.6	15,716	90.9
Peripheral vascular disease	3,243	18.8	2,279	13.2
Congestive heart failure	4,718	27.3	4,034	23.3
Coronary artery disease	7,297	42.2	6,597	38.2
Chronic kidney disease	4,373	25.3	3,783	21.9
Chronic lung disease	5,298	30.6	4,488	26.0
Chronic liver disease	1,070	6.2	996	5.8
Thyroid disease	6,882	39.8	6,525	37.7
Depression	6,753	39.1	6,066	35.1

BMI = body mass index

Table 3

Surgical Complication Rates After Anatomic Total Shoulder Arthroplasty in Patients With Osteoporosis and Matched Controls

Complications (2 yr)	Osteoporosis (N = 17,078)	Controls (N = 17,078)	Statistical Analysis OR (95% CI)	*P* Value
Loosening/ osteolysis	215 (1.3%)	178 (1.0%)	1.12 (0.92-1.37)	0.266
Periprosthetic fracture	100 (0.6%)	59 (0.3%)	1.49 (1.08-2.07)	0.017
Periprosthetic dislocation	375 (2.2%)	292 (1.7%)	1.16 (0.99-1.36)	0.064
Revision shoulder arthroplasty	473 (2.8%)	358 (2.1%)	1.21 (1.09-1.34)	0.009

CI = confidence interval, OR = odds ratio

(Table 3). Patients with a diagnosis of osteoporosis who underwent RSA also had significantly higher rates of periprosthetic fracture (OR, 1.86; 95% CI, 1.49 to 2.32; $P = 0.001$) and revision shoulder arthroplasty (OR, 1.42; 95% CI, 1.26 to 1.60; $P = 0.005$) within 2 years of surgery compared with matched controls without osteoporosis (Table 4). No significant increases were seen in prosthetic dislocation or loosening/ osteolysis for either the TSA or RSA patients compared with matched controls.

Discussion

The current study identified the high prevalence of the diagnosis of osteoporosis in both the anatomic and reverse shoulder arthroplasty population and demonstrated that patients with a diagnosis of osteoporosis who underwent anatomic TSA and RSA were at an increased risk of implant-related complications. Both groups were found to be at an increased risk of periprosthetic fracture and revision surgery within 2 years compared with a matched control cohort of patients undergoing shoulder arthroplasty without a diagnosis of osteoporosis.

Osteoporosis is a bone disease defined by an increased susceptibility to fracture due to decreased BMD. The disease currently affects more than 8 million women and 2 million men in the United States, with an addition of 34 million Americans having low bone mass. This condition has been shown repeatedly to lead to low-energy fractures, especially hip fractures, which markedly alters long-term function and is associated with a high mortality rate.[14] With the increasing prevalence of osteoporosis in the population, it has come into the realm of the orthopaedic surgeon.[1]

As the patient population increases in age, the likelihood of them having

osteoporosis increases. In the current study, a significant number of patients undergoing both anatomic and reverse TSA had a concurrent diagnosis of osteoporosis at the time of surgery, which is similar to the findings in the lower extremity joint arthroplasty literature, in which Lingard et al found that 23% of patients aged 65 to 80 years and awaiting a total hip or knee replacement had osteoporosis, and an additional 43% had osteopenia, whereas a separate similar study found very similar percentages.[15,16] These studies have demonstrated the prevalence of osteoporosis in this older patient population awaiting lower extremity arthroplasty.

Table 4

Surgical Complication Rates After Reverse Total Shoulder Arthroplasty in Patients With Osteoporosis and Matched Controls

Complications (2 yr)	Osteoporosis (N = 17,287)	Controls (N = 17,287)	Statistical Analysis	
			OR (95% CI)	*P* Value
Loosening/ osteolysis	171 (1.0%)	126 (0.7%)	1.22 (0.96-1.54)	0.107
Periprosthetic fracture	127 (0.7%)	60 (0.3%)	1.86 (1.49-2.32)	0.001
Periprosthetic dislocation	340 (2.0%)	270 (1.6%)	1.13 (0.96-1.34)	0.138
Revision shoulder arthroplasty	413 (2.4%)	297 (1.7%)	1.42 (1.26-1.60)	0.005

CI = confidence interval, OR = odds ratio

The lower extremity arthroplasty literature has also demonstrated the significant risk that osteoporosis imparts on developing a periprosthetic proximal femur fracture.[17-19] These fractures pose a significant morbidity and often need revision surgery, which not only affects patient care but imparts a significant economic burden to the healthcare system.[20,21] Some have even advocated delaying surgery and treating the severe osteoporosis before undergoing total hip arthroplasty due to the risk and morbidity associated with a fracture. With the rate of osteoporosis increasing, the trend will likely be similar in the shoulder arthroplasty population. The morbidity to the patient and cost to the healthcare system overall can be substantial for complications associated with this condition. Furthermore, osteoporosis can make the index surgery more difficult, as achieving adequate implant fixation becomes problematic with lower quality bone, and could potentially lead to intraoperative complications or a longer surgery. This has been demonstrated in the noncemented total hip arthroplasty population, in that low BMD is associated with slower osseointegration and decreased early stability.[22]

We found that osteoporosis represents a significant, independent risk factor for periprosthetic fracture and revision shoulder arthroplasty within 2 years of surgery, regardless of the type of implant. This finding aligns with the findings for lower extremity arthroplasty, where the risk of periprosthetic fracture increased with those who were elderly and had a diagnosis osteoporosis.[12,13] Osteoporosis has such an effect on the implantation of arthroplasty that even pin holes from navigated total knee replacements have been demonstrated to be a site of potential periprosthetic fracture.[23] One particularly interesting caveat is that although osteoporosis was associated with an increased risk of periprosthetic fracture, there was no increased risk of loosening or osteolysis, which is surprising. However, this may be a function of implant fixation methods; patients with known osteoporosis may be more likely to receive cemented components, which would be at lower risk for loosening or osteolysis. Implant records and surgical reports are not available to delineate this further.

One of the indications for the reverse shoulder arthroplasty is an osteoporotic proximal humerus fracture, so it is not particularly surprising that osteoporosis places patients at a higher risk of periprosthetic fracture in the reverse TSA group. Therefore, the reverse TSA population would seem to be at a baseline increased risk of this complication. A large majority of patients sustaining a proximal humerus fracture have low BMD, and reverse shoulder arthroplasty has been shown to be a good surgical option because of the poor clinical and functional outcomes of traditional fixation methods.[11,24-27] However, despite this link between osteoporotic fracture and reverse shoulder arthroplasty, osteoporosis still confers an increased risk of periprosthetic fracture even in the anatomic TSA group.

This study is limited by the fact that it relies on the availability and accuracy of the coded data within the database. The quality is contingent on coding accuracy, so errors on the part of medical billing personnel or physicians may inadvertently omit patients or fail to list them as having a relevant diagnosis. However, a recent Centers for Medicare & Medicaid Services report from 2012 cited an overall coding error rate of 1.3%.[28] Therefore, although the accuracy is a major concern when using administrative databases such as PearlDiver, the overall coding error rate is low. Although the robustness of the analysis is limited by the quality of

the data, the large number of patients in the PearlDiver database may also dilute small errors.

Second, osteoporosis is a spectrum of disease. The exact BMD score, such as a *z*- or *t*-score, is not available within the data. This measure of severity of the disease likely has a significant effect on the overall bone quality and has been shown to correlate with fracture risk.[29] This phenomenon may be a source of error because not all patients within this study would have a homogenous fracture risk. Furthermore, using *ICD-9* coding to define patients with osteoporosis, while necessary in a database study, may lead to a reporting bias. While the knowledge of the disease, and thus diagnosis of the disease have improved drastically, there are likely patients with osteoporosis who do not carry a diagnosis code for it in their medical records. As a result, one would expect that osteoporosis would be underreported, which would dilute the effect of the osteoporosis. However, there are still significant implant-related complications even with this potential reporting bias. In addition, many patient identifiers and risk factors were controlled for in our analysis, and no specific surgical details are available. For example, we could not control for specific implant design or whether cement was used on implantation, both of which could potentially affect the outcomes we measured.

Third, the selection of the patients used in this study may limit the applicability of results. The goal in creating the study population from the available data was to generate an accurate cross section of the population within the United States. However, using only Medicare patients might mean that our conclusions cannot be extrapolated to a younger, private-payer patient population.

Finally, patients may have dropped from the Medicare insurance rolls during the study period. Although this number is likely small, outcomes for these patients would not be available because the data are indexed only from 2005 to 2014. Similarly, patients who had a complication outside the time frame would also not be included in this analysis.

A significant number of patients undergoing both anatomic and reverse TSA have a concurrent diagnosis of osteoporosis at the time of surgery. Osteoporosis represents a significant independent risk factor for periprosthetic fracture and revision shoulder arthroplasty within 2 years of surgery, regardless of the type of implant. Patients with osteoporosis should be counseled on their increased risk of complications after shoulder arthroplasty. Further work is needed to determine optimal treatment pathways to decrease the risk of periprosthetic fracture and revision surgery.

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