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Parkinson's disease and shoulder arthroplasty: a systematic review

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Background: Parkinson's disease (PD) is a neurodegenerative disorder associated with inferior clinical outcomes after surgical management of many orthopedic conditions. The purpose of this systematic review was to define the clinical, functional, and patient-reported outcomes of shoulder arthroplasty (SA) in patients with PD.

Methods: Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a systematic search was completed using the Ovid platform for searches in MEDLINE, EMBASE, Cochrane Central, and Cochrane Systematic Reviews, with additional searches in Web of Science and Scopus. Included studies were full-length, English-language, clinical investigations reporting on SA in patients with PD with at least one clinical outcome.

Results: Seven studies including 7126 patients (7134 SA) met inclusion criteria with a mean age of 72.6 (range, 69.5–75.8 years), 58.9% female, and the average follow-up duration was 65 months (range, 17–119 months). Anatomic total shoulder arthroplasty (aTSA) was the most reported implant surgery (n = 3455, 48.4%) followed by hemiarthroplasty (HA) (n = 2840, 39.8%), and reverse shoulder arthroplasty (RSA) (n = 839,1.8%). SA consistently improved pain. Forward elevation, abduction, and external rotation had a pooled mean increase of 36°, 20°, and 6°, respectively. Complications occurred at a pooled rate of 22.5%, with stiffness (7.1%), need for revision (5.3%), and instability (4.7%) as the most common complications reported. Reoperations inclusive of revisions occurred at a lower pooled rate of 5.6%, with aTSA (n = 201; 9.0%) having the highest rate, followed by HA (n = 158; 7.1%), and then RSA (n = 42; 1.9%).

Conclusions: The results of the present systematic review demonstrate that SA in patients with PD results in consistent pain relief. However, inferior improvements in clinical outcomes may be expected when compared with patients without PD, likely due to the neurodegenerative manifestations of this disorder. In addition, RSA had a lower reoperation rate than HA and aTSA in patients with PD.

Parkinson's disease (PD) is the second most common neurodegenerative disorder after Alzheimer's disease.[8] The annual incidence of PD is 20.5 cases per 100,000 individuals, with a lifetime risk of 2% in men and 1.3% in women.[8,11] Disease onset typically follows a progressive course after 50 years of age with a wide spectrum of clinical symptoms.[13] Motor symptoms include bradykinesia, muscle rigidity, flexed posture, asymmetric limb resting tremor, and postural instability, while nonmotor symptoms are cognitive impairment and depression.[13,16]

In orthopedics, prior investigations have demonstrated successful pain relief but marginal functional benefits and increased perioperative complications after total knee and hip arthroplasties in patients with PD.[12,14,17] The limited functional results after lower limb arthroplasty were attributed to certain clinical disease symptoms, such as severe tremor, preexisting muscle rigidity, and dystonia.[1,12,14,17] Although most of the arthroplasty studies in patients with PD has been conducted on the lower extremity, the upper extremity is more commonly involved with tremor and choreiform movement.[6] As such, some have proposed even greater rates of failure and complication rates in patients with PD after shoulder arthroplasty (SA).[7,9,10]

The current literature evaluating SA in patients with PD is generally limited to small retrospective studies and case reports.[9,10]

Mayo Clinic Institutional Review Board approved this study (PR12-007498-04).

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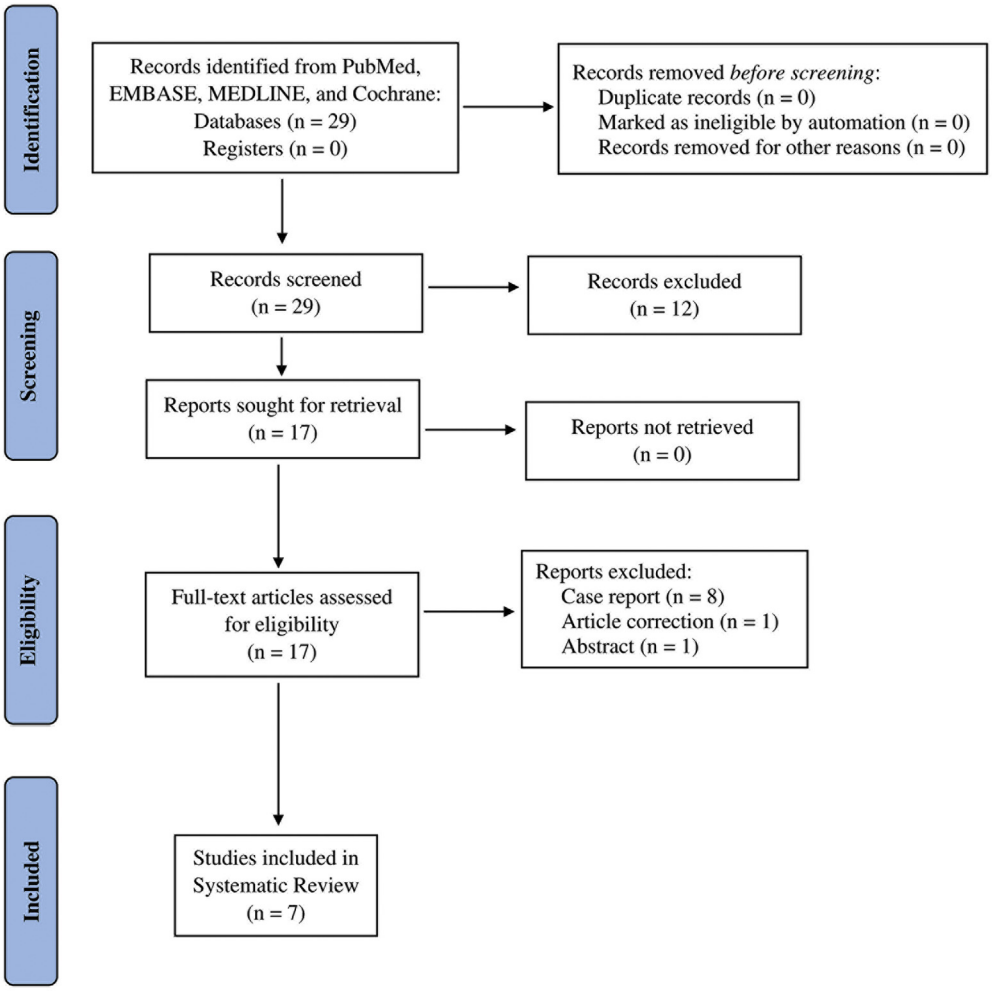

Figure 1 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) flowchart of articles identified.

Publications available to date do suggest that patients with PD are at higher risk for complications after any type of SA because of the various motor, cognitive, and metabolic factors arising from the neurodegenerative pathology.[5] However, characterizing and comparing the perioperative complications in patients with PD undergoing SA has been difficult because of the relatively low incidence of these procedures in patients with the disease. As such, the purpose of this study was to systematically review the evidence in the current literature to evaluate the clinical, functional, and patient-reported outcomes of SA in patients with PD.

Methods

Literature search

This systematic review investigating the outcomes of PD in SA was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta analyses) 27-item checklist (Fig. 1). The comprehensive literature review was completed on June 8, 2021, using MEDLINE, Embase, and Cochrane, Web of Science, and Scopus library databases. Search terms included "Parkinson's disease", "Parkinson's", "shoulder arthroplasty", "shoulder replacement", "hemiarthroplasty", "anatomic total shoulder arthroplasty", and "reverse total shoulder arthroplasty". The formal strategy listing all search terms used and how they are combined is included in the Supplementary Appendix S1.

Eligibility criteria and study selection

The inclusion criteria consisted of full-length publications written in the English language, publication in a peer-reviewed journal, level IV evidence or higher, and presence of at least 1 reported clinical outcome (common shoulder functional outcomes, complications, reoperations, or readmission). Exclusions entailed abstract-only reports, case reports, expert opinions, literature reviews, and studies with no reported outcomes.

Data extraction

The search strategy was designed and conducted by an experienced librarian with input from the study investigators. Study demographics were subsequently collected by 2 blinded reviewers. These included the articles' author, publication year, study design, and level of evidence. Further patient-specific characteristics collected included sample size, mean age, sex, follow-up interval, arthroplasty type, functional outcome data, radiographic outcome data, complication rates, reoperations, and patient-reported outcome measures.

Table 1
Study characteristics and patient demographics.

Study	LOE	No. of patients	All SA	HA	Implants TSA	RSA	Age, yr	Male sex, n (%)	Follow-up, mo
Koch et al (1997)[7]	IV	15	16	–	16	–	70	7 (43.8)	64
Kryzac et al (2009)[9]	IV	42	49	–	49	–	70	32 (65.3)	96
Kryzac et al (2010)[10]	IV	7	7	7	–	–	72	5 (71.4)	119
Dunn et al (2011)[5]	IV	3	3	–	–	3	75	0 (0)	17
Burrus et al (2015)[3]	III	7032	7032	2833	3390	809		2874 (40.9)	NR
Cusick et al (2017)[4]	III	10	10	–	–	10	76	4 (40)	43
Borbas et al (2021)[2]	III	17	17	–	–	17	74	7 (41.2)	50
Total	–	7126	7134	2840 (39.8%)	3455 (48.4%)	839 (11.8%)	72.7	2929/7134 (41.1)	65

LOE, level of evidence; *SA*, shoulder arthroplasty; *HA*, hemiarthroplasty; *TSA*, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty; *NR*, not reported.
All values are reported as the number and percentage except when noted.

Statistical analysis

Statistical analysis was performed with the combination of Microsoft Excel (Version 16.0.1; Microsoft Corp., Redmond, WA, USA) and JMP Pro (Version 14.1.0; SAS Institute, Cary, NC, USA). Descriptive statistics were presented as means, medians, percentages, and standard deviation when appropriate. Continuous variables were analyzed using Student t tests or Wilcoxon rank-sum tests. Categorical variables were analyzed using Chi-square analysis or Fisher exact tests. When available, raw data were extracted and reported as pooled means if possible. Investigations with individual raw patient data without means and standard deviations were manually included into Microsoft Excel for inclusion into the final calculations. P values < .05 were considered statistically significant.

Results

Study characteristics and patient demographics

The initial literature search resulted in 29 total studies. No duplicates were present, and all 29 studies were screened for inclusion and exclusion criteria. Subsequently, 17 unique studies were identified as potentially relevant, and full texts were assessed for eligibility. Seven clinical studies met criteria to be included in this systematic review, as demonstrated in Figure 1. A total of 7134 shoulders in 7126 patients were included in the analysis. Mean patient age at the time of arthroplasty was 72.6 (range, 69.5 − 75.8) years, 58.9% were female, and the average follow-up duration was 65 months (range, 17 − 119 months). Anatomic total shoulder arthroplasty (aTSA) was the most reported implant procedure (n = 3455, 48.4%), followed by hemiarthroplasty (HA) (n = 2840, 39.8%), and reverse shoulder arthroplasty (RSA) (n = 839, 11.8%) (Table I).

Clinical and functional outcome measures

Six out of the seven studies (n = 102) reported pain as an outcome measure, all reporting general improvement after SA (Table II).[2,4,5,7,9,10] Three studies (n = 30) measured forward elevation, with a pooled postoperative mean of 75°.[2,4,5] Of these investigations, two had preoperative data available demonstrating a pooled mean increase of 36° postoperatively.[2,4] Five studies (n = 99) measured abduction, with a pooled postoperative mean 97° and a mean increase of 20° postoperatively.[2,4,7,9,10] Six studies (n = 102) measured external rotation, with a pooled postoperative mean of 27° and a mean increase of 6° postoperatively.[2,4,5,7,9,10] Five studies (n = 99) measured internal rotation with various reporting scales, none demonstrated any significant improvements from baseline (Table II).[2,4,7,9,10]

Cusick et al[4] (n = 10) was the only study to report American Shoulder and Elbow Surgeons score (ASES) and simple shoulder test outcomes with a mean improvement of 33.7 to 51.0 (P = .047) and 1.3 to 3.8 (P = .024), respectively. Borbas et al[2] (n = 17) was the only study to report SSV, absolute Constant-Murley score, and relative Constant-Murley bow score with mean improvements of 33.9 to 57.8 (P = .005), 26.8 to 48.7 (P < .001), and 35 to 61.5 (P < .001), respectively. Three studies (n = 66) reported outcome measures using the Neer result rating scale, with pooled categories of 24% excellent, 26% satisfactory, and 50% unsatisfactory.[7,9,10]

Shoulder-related complications, reoperations, and revisions

All studies reported on postoperative complications with a pooled rate of 22.5% (1607/7134) (Table III). Stiffness was the most common pooled complication (n = 505; 7.1%), followed by an unlisted need for revision (n = 381; 5.3%), and then instability (n = 381; 4.7%). When tiered by implant, stiffness, need for revision, and instability remained the top three categories for HA, TSA, and RSA (Table IV). Reoperations inclusive of revisions occurred at a pooled rate of 5.6% (401/7134), with revisions accounting for 398 of 401 reoperations also occurring at a pooled rate of 5.6%. When categorized by implants, aTSA had the highest reoperation rate (n = 201; 9.0%) followed by HA (n = 158; 7.1%), and then RSA (n = 42; 1.9%).

Discussion

PD is a neurodegenerative disorder that presents a clinical challenge with respect to surgical management of orthopedic conditions, including SA. Studies examining outcomes of SA in PD are scarce, with the available data limited to smaller retrospective investigations. The results of our systematic review indicate that SA provided patients with PD adequate pain relief. However, functional benefits after SA remained limited, with small increases in ROM and marginal patient-reported outcome improvements. Complications occurred at a pooled rate of 22.5%, with stiffness (7.1%), need for revision (5.3%), and instability (4.7%) as the most common issues. Despite this, reoperations inclusive of revisions occurred at a lower pooled rate of 5.6%, with aTSA (9.0%) having the highest rate, followed by HA (7.1%), and RSA (1.9%) with the lowest rate.

The clinical studies included in this review all demonstrated improvement in pain after SA. Koch et al[7] first evaluated the effects of SA in 15 PD patients, demonstrating discouraging functional results but reasonable success in pain relief after unconstrained aTSA. In a further review of subsequent studies with matched cohorts, Cusick et al[4] demonstrated similar postoperative VAS pain and ASES pain scores of PD patients to a matched RSA cohort. Similarly, Borbas et al[2] observed equivalent pain improvement after RSA in patients with PD compared with their matched cohort. Unlike pain relief, functional improvement in this cohort has historically been poor.[7] In the present review, forward elevation had a pooled postoperative mean of 75° with mean increases of

Table 2
Clinical and functional outcomes per study included.

Study	Pain scores			Range of motion (degrees)			Pain reported outcomes				Neer result rating
	Descriptive	VAS	NRS	FE	ABD	ER	IR	ASES	SSV	SST	aCS	rCS	
Koch et al (1997)[7]	Pre: 38% severe	Pre: NR	Pre: NR	Pre: NR	Pre: 106 ± 33	Pre: 29 ± 24	Pre: L4	Pre: NR	Pre: NR	Pre: NR	Pre: NR	Pre: NR	25% Excellent 13% Satisfactory 62% Unsatisfactory
	Post: 6% severe	Post: NR	Post: NR	Post: NR	Post: 98 ± 36	Post: 45 ± 27	Post: L4	Post: NR	Post: NR	Post: NR	Post: NR	Post: NR	
Kryzac et al (2009)[9]	NR	4.6	NR	NR	100	21	Sacrum	NR	NR	NR	NR	NR	23% Excellent 30% Satisfactory 47% Unsatisfactory
	NR	1.8	NR	NR	119	44	L5	NR	NR	NR	NR	NR	
Kryzac et al (2010)[10]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	29% Excellent 29% Satisfactory 43% Unsatisfactory
	2.5/5	NR	NR	NR	97	38	Sacrum	NR	NR	NR	NR	NR	
Dunn et al (2011)[5]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
	NR	0.7	NR	41 ± 20	NR	8.3 ± 7.6	NR	NR	NR	NR	NR	NR	
Burrus et al (2015)[3]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	
Cusick et al (2017)[4]	NR	6.3 ± 1.2	NR	48 ± 34	48 ± 27	23 ± 21	1.3 ± 0.9	33.7 ± 18.6	NR	1.3 ± 1.1	NR	NR	
	NR	3.9 ± 1.2	NR	91 ± 34	80 ± 27	16 ± 21	2.3 ± 0.9	51.0 ± 18.6	NR	3.8 ± 1.1	NR	NR	
Borbas et al (2021)[2]	NR	NR	6.8 ± 4.7	64 ± 34	56 ± 23	20 ± 17	3.2 ± 2.1	NR	33.9 ± 17.7	NR	26.8 ± 14.6	35 ± 17.7	
	NR	NR	12.4 ± 3.3	92 ± 32	92 ± 31	10 ± 16	3.4 ± 1.5	NR	57.8 ± 27.8	NR	48.7 ± 14.6	61.5 ± 18.3	

VAS, visual analog scale; *NRS*, numeric rating scale; *FE*, forward elevation; *ABD*, abduction; *ER-0*, external rotation with the shoulder at zero degrees of FE; *IR-0*, internal rotation with the shoulder at zero degrees of FE; *ASES*, American Shoulder and Elbow Surgeons score; *SSV*, subjective shoulder value; *SST*, simple shoulder test; *aCS*, absolute Constant-Murley score; *rCS*, relative Constant-Murley bow score; *NR*, not reported.

abduction to 36° and external rotation to 6°, with these differences remaining below the described minimal clinically important differences after TSA and RSA.[15]

In addition, patient-reported outcomes and satisfaction were also marginal. In studies including the Neer rating scale, up to 50% of SA had an unsatisfactory result, notably implants included were either HA or aTSA.[7,9,10] Despite this, some benefits after RSA have been reported by Cusick et al,[4] with improvements of ASES and simple shoulder test similar to matched controls. Borbas et al[2] also noticed improvement in SSV, absolute Constant-Murley score, and relative Constant-Murley bow score but at lower postoperative values than matched RSA controls. These outcomes are likely affected by the poor muscle control, rigidity, and bradykinesia of PD, which may limit the ability of SA and associated implants to improve the compromised shoulder girdle. To combat this, modifications of the surgical technique to include appropriate soft-tissue releases, optimized component positioning, early mobilization, prolonged physical therapy, and botulinum toxin A use have been described with unclear benefits.[2-5,7,9,10]

In this review, complications remained a notable problem, with a pooled rate of 22.5%. Postoperative stiffness was the most often described complication, at a rate of 7.1%, which is consistent with the ROM findings in the literature. Although soft-tissue tension and component positioning play a role in subsequent ROM, the ability to successfully engage in physical therapy likely also contributes to the outcome. As such, the combination of rigidity, bradykinesia, and dementia may translate into a limited ceiling for postoperative ROM improvements in these patients. Instability was also observed at an elevated rate of 4.7%. Initial investigations highlighted that this may be an issue limited to unconstrained SA, but more recent studies including this review continued to demonstrate higher rates of instability in RSA as well.[2,4] As patients with PD have asynchronous motor function, constant tremors, and lack complete volitional muscle control, this may place the shoulder at elevated risks of implant loosening and instability events.

In the present review, reoperations inclusive of revisions occurred at a pooled rate of 5.6%, with revision arthroplasty accounting for 99.3% of described reoperations (398 of 401). In studies with matched cohorts, PD demonstrated higher reoperation rates than their respective RSA control groups.[2,4] Similarly, Burrus et al[3] demonstrated an independent increase in revision rates after HA, aTSA, and RSA when compared with matched controls in a large national database investigation. In a review of their indications for revisions, they included traditionally common reasons for revision SA: instability, infection, periprosthetic fracture, and component loosening. As such, the observed increased risk of complications in patients with PD remains multifactorial and likely stems from the underlying manifestations of the disease, including the motor and nonmotor components. Interestingly, when reoperation was compared by implant type, RSA demonstrated a lower pooled rate of 1.9% than the 9.0% in aTSA and 7.1% in HA. This may suggest that RSA may be more accommodating of PD with respect to subsequent revision. However, this outcome may also be limited by the shorter follow-up of RSA studies because of the more recent introduction of the implant as compared to HA and aTSA.

Although this systematic review provides a broad overview of SA in the context of PD, it should be viewed within the context of certain limitations. The present investigation limited the search to articles with full text published in the English language, which may have resulted in exclusion of other relevant literature as well as potential selection bias. Subsequently, this study included many heterogenous retrospective studies spanning multiple decades with different numbers of patients, follow-up intervals, measured clinical outcomes, and varied implant use with unknown details on the surgical indications. In addition, most of the included patients

Table 3
Postoperative shoulder-related complications, reoperations, and revision rates per study.

Study	Complications	Reoperations/revisions
Koch et al (1997)[7]	aTSA – 7 (43.8%) total: 3 (18.8%) aseptic humeral component loosening 2 (12.5%) subluxation 2 (12.5%) aseptic glenoid loosening	aTSA – 3 (18.8%) revisions in total: 2 (12.5%) symptomatic subluxation 1 (6.3%) glenoid loosening
Kryzac et al (2009)[9]	aTSA – 10 (20.4%) total: 3 (6.1%) aseptic glenoid loosening 3 (6.1%) instability 2 (4.1%) asymptomatic glenoid shifts 1 (2%) aseptic humeral component loosening 1 (2%) periprosthetic fracture	aTSA – 8 (16.3%) revisions in total: 3 (6.1%) aseptic glenoid loosening 3 (6.1%) instability 1 (2%) aseptic humeral component loosening 1 (2%) periprosthetic fracture
Kryzac et al (2010)[10]	HA – 4 (57.1%) total: 3 (42.9%) greater tuberosity malunion 1 (14.3%) greater tuberosity nonunion	HA – 0 (0%) revisions in total
Dunn et al (2011)[5]	RSA – 3 (100%) total: 1 (33.3%) persistent pain 1 (33.3%) periprosthetic fracture 1 (33.3%) instability	RSA – 3 (100%) revisions in total: 1 (33.3%) revision for persistent pain 1 (33.3%) periprosthetic fracture 1 (33.3%) instability
Burrus et al (2015)[3]	HA – 704 (24.8%) total: 209 (7.4%) stiffness 158 (5.6%) unlisted need for revision 145 (5.1%) dislocations 91 (3.2%) periprosthetic fractures 66 (2.3%) infections 35 (1.2%) aseptic component loosening	HA – 158 (5.6%) revisions in total
	HA – 704 (24.8%) total: 209 (7.4%) stiffness 158 (5.6%) unlisted need for revision 145 (5.1%) dislocations 91 (3.2%) periprosthetic fractures 66 (2.3%) infections 35 (1.2%) aseptic component loosening	HA – 158 (5.6%) revisions in total
	aTSA – 691 (20.4%) total: 237 (7.0%) stiffness 190 (5.6%) unlisted need for revision 136 (4.0%) dislocations 55 (1.6%) infections 39 (5.6%) aseptic component loosening 34 (1.0%) periprosthetic fractures	aTSA – 190 (5.6%) revisions in total
	RSA – 175 (21.6%) total: 59 (7.3%) stiffness 45 (5.6%) dislocations 33 (4.1%) unlisted need for revision 27 (3.3%) infections 11 (1.4%) periprosthetic fractures	RSA – 33 (4.1%) revisions in total
Cusick et al (2017)[4]	RSA – 4 (40%) total: 2 (20%) postoperative acromial fractures 1 (10%) glenoid baseplate component failure 1 (10%) instability	RSA – 1 (10%) revision in total: 1 (10%) case of recurrent instability
Borbas et al (2021)[2]	RSA – 10 (58.8%) total: 3 (17.6%) postoperative scapular spine fracture 2 (11.8%) periprosthetic humeral fracture 2 (11.8%) aseptic glenoid loosening 1 (5.9%) instability 1 (5.9%) infection 1 (5.9%) postoperative acromial fracture	RSA – 5 (29.4%) reoperations in total: 2 (11.8%) ORIF of scapular spine 1 (5.9%) arthroscopic acromioplasty of scapular spine fracture 2 (11.8%) revisions in total 1 (5.9%) periprosthetic humeral fracture 1 (5.9%) acromial fracture

aTSA, anatomic total shoulder arthroplasty; *HA*, hemiarthroplasty; *RSA*, reverse shoulder arthroplasty; *ORIF*, open reduction internal fixation.

were acquired from the study by Burrus et al,[3] which heavily influences the current analysis, especially the rates of complications and revision surgery. Therefore, it was difficult to consistently pool all variables to generate a complete meta-analysis. As such, the present investigation performed a qualitative systematic review with quantitative calculations whenever feasible.

Conclusion

The results of the present systematic review demonstrate that SA in patients with PD likely results in consistent pain relief. However, inferior improvements in clinical outcomes may be expected, likely due to the neurodegenerative manifestations of this disorder. An elevated rate of complications was observed in the literature with a pooled rate of 22.5%. However, revisions were much lower with a 5.6% pooled rate. RSA may be the most accommodating implant type to PD, with a lower rate of revisions.

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Table 4
Pooled shoulder-related complications categorized by implant type.

Complications	HA (n = 2840)		aTSA (n = 3455)		RSA (n = 839)		All SA (n = 7134)	
	No.	%	No.	%	No.	%	No.	%
Stiffness	209	7.4	237	6.9	59	7.0	505	7.1
Unlisted need for revision	159	5.6	190	5.5	33	3.9	381	5.3
Instability	145	5.1	141	4.1	48	5.7	334	4.7
Infections	66	2.3	55	1.6	28	3.3	149	2.1
Periprosthetic fracture	91	3.2	35	1.0	14	1.7	140	2.0
Aseptic component loosening	35	1.2	39	1.1	0	0.0	74	1.0
Aseptic glenoid loosening	0	0.0	7	0.2	3	0.4	10	0.1
Acromial/scapular spine fractures	0	0.0	0	0.0	6	0.7	6	0.1
Aseptic humeral component loosening	0	0.0	4	0.1	0	0.0	4	0.1
Greater tuberosity malunion	3	0.1	0	0.0	0	0.0	3	0.0
Greater tuberosity nonunion	1	0.0	0	0.0	0	0.0	1	0.0
Total	709	25.0	708	20.5	191	22.8	1607	22.5

HA, hemiarthroplasty; *aTSA*, anatomic total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty; *SA*, shoulder arthroplasty.
All values are reported as the number and percentage except when noted.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2021.11.004.

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