Revision of reverse shoulder arthroplasty by indication

a National Joint Registry study

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Aims

Reverse shoulder arthroplasty (RSA), initially designed for cuff tear arthropathy (CTA), is now the most common choice of shoulder arthroplasty in both elective and trauma settings in the UK. Its use has rapidly increased for several indications, including osteoarthritis (OA) with an intact rotator cuff, acute trauma, and trauma sequalae. This study aims to review the revision rates of RSA by indication to assess how the implant is performing for indications for which it was not primarily designed.

Methods

Data from the National Joint Registry were obtained from 1 April 2012 to 31 March 2022. Data were linked to Hospital Episode Statistics for England and National Mortality Data. RSAs were identified and sorted into mutually exclusive groups by indication. The primary outcome was first revision and the secondary outcome was non-revision reoperation.

Results

The revision rates for RSA for CTA were 1.53% (95% CI 1.31 to 1.78) at one year, 3.21% (95% CI 2.86 to 3.60) at five years, and 4.97% (95% CI 4.23 to 5.84) at nine years. For primary OA, they were 1.21% (95% CI 0.95 to 1.54) at one year, 2.71% (95% CI 2.25 to 3.37) at five years, and 5.00% (95% CI 3.62 to 6.88) at nine years. For trauma, they were 1.51% (95% CI 1.15 to 1.99) at one year and 2.67% (95% CI 2.07 to 3.43) at five years. For trauma sequalae, they were 4.25% (95% CI 3.4 to 5.29) at one year and 7.12% (95% CI 5.90 to 8.59) at five years. Between indications, the revision rates were not statistically different except for trauma sequalae, which had a significantly increased risk of revision ($p \leq 0.001$). Incidence of non-revision reoperation across the cohort was 1.1% (n = 283 patients), with the most common being manipulation under anaesthesia with or without capsular release (42.03%, n = 124) followed by subacromial decompression (21.02%, n = 62).

Conclusion

This study reports on the range of indications for which RSA is being used in the UK. It demonstrated that, based on the largest analysis of RSA across a range of indications, the revision rates and secondary surgery rates are broadly similar except for trauma sequalae.

Take home message

- Despite being designed for cuff tear arthropathy, reverse shoulder arthroplasty is being used for a range of indications in the UK.

- Revision rates and secondary surgery are broadly similar between indications except for trauma sequalae.
- Some of the indications with smaller populations in the registry require further analysis, particularly trauma sequelae, which was found to have a higher revision rate.

Introduction

Shoulder arthroplasty in the UK is increasing year on year. Despite being designed for cuff tear arthropathy (CTA), a stemmed reverse shoulder arthroplasty (RSA) is now the most common choice of implant in both elective and trauma settings.[1] This trend has been mirrored worldwide with an increase from 2011 to 2017 of 22,835 to 62,705 RSAs being performed per annum in the USA, and stemmed RSA increasing as a proportion of shoulder arthroplasties in Australia from 50% in 2011 to over 80% in 2022.[2,3] The increased use of RSA is, in part, due to a broadening of indications to include patients with an irreparable cuff tear without arthritis, osteoarthritis (OA) with an intact cuff, acute trauma, and trauma sequalae.[4,5]

For all implants (RSA, total shoulder arthroplasty (TSA), and hemiarthroplasty (HA)), the estimated cumulative risk of revision at five years for elective shoulder arthroplasty in the UK is 4.2%, and this is affected by age and implant type. Females have a lower risk of revision compared with males, and younger patients have an increased risk of revision compared with older patients.[1] This is especially true for patients aged under 55 years who, after three years, have substantially higher revision rates at each subsequent timepoint.[1] An analysis of Hospital Episode Statistics (HES)[6] data showed the lifetime risk of implant revision ranged from 2.7% (95% CI 2.6 to 2.8) in females aged 85 years and older to 23.6% (95% CI 23.2 to 24.0) in males aged 55 to 59 years.[7] The 2023 National Joint Registry (NJR) annual report shows a lower revision rate at the ten-year follow-up for RSA in comparison with both TSA and HA.[1] There is concern that this may not be truly reflective of the implant's performance, as the original demographic of elderly patients receiving a RSA may accept poorer long-term function or surgeons may choose not to operate in this population due to comorbidities and the technical difficulty of the procedure. When a primary shoulder arthroplasty is revised, there is currently no consensus on implant selection, although there is a trend towards RSA as the favoured option.[8,9] Further research into RSA has been deemed of high priority by the National Institute for Health and Care Excellence (NICE).[10]

The NJR has routinely collected data on shoulder arthroplasty from England, Wales, Northern Ireland, Isle of Man, and the States of Guernsey since 2012 and can be linked to HES for England, which is further linked to the Office for National Statistics (ONS) mortality register.[11] This study aims to evaluate the rate of revision and reoperation of RSA across the multiple indications.

Methods

Data source

Data were extracted from the NJR from April 2012 to March 2022. Surgical indications captured by the NJR include: CTA, OA, rotator cuff tear without arthropathy, dislocation arthropathy, inflammatory arthropathy (IA), metastasis or malignancy, acute trauma, and trauma sequalae. The NJR dataset also includes patient demographics, operation details, and revision operations. This dataset was linked to the HES database, which includes details of patients' admissions to an NHS hospital and to independent hospitals that provide NHS care across England. The HES database is linked to the ONS database, which is refreshed monthly. Simultaneous bilateral operations were removed to allow linkage of the databases.

Inclusion

All RSAs that could be linked to the HES database were included. A total of 7.34% (n = 1,938) of cases had been coded for multiple indications, and these were sorted into mutually exclusive groups; a full explanation of this is detailed in the Supplementary Material, and where this was not possible, they were removed from the analysis.

Outcomes

The primary outcome was first revision. Revision was defined as any operation where one or more components are added to, removed from, or modified in a joint arthroplasty, or if a debridement and implant retention with or without modular exchange is performed, and these were identified using the NJR database.[1] The secondary outcome was reoperation. Reoperations were identified from the HES database using Office of Population Censuses and Classification of Intervention and Procedures v.4.9 (OPCS-4.9) codes and included subacromial decompression, rotator cuff repair, stabilization, relocation, manipulation under anaesthesia (MUA) with or without capsular release, synovectomy, and fracture fixation (Supplementary Table i).[12]

Statistical analysis

Summary statistics are provided for each of the revision indications. The Kaplan-Meier method was used to analyze time to event data for implant survival at one, three, five, seven, and nine years. The 95% CIs were calculated. Hazard ratios for the revision rate compared with RSA for CTA (primary design indication) were calculated using a Cox proportional hazards model. The model was then adjusted for age, sex, and Charlson Comorbidity Index (CCI).[13] The CCI was calculated using International Classification of Diseases (ICD)-10 codes from the HES database (Supplementary Table ii).[14] The unadjusted Cox model satisfied the proportional hazards assumption; however, when the confounders of age and sex were introduced, the hazards assumption was violated. To address this, the model was stratified by age and sex, allowing the baseline hazard to vary across these strata. The proportional hazards assumption was tested using log-log plots and Schoenfeld residuals for sub-groups created by the intersection of age and sex, and the assumption held for all subgroups. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were adhered to in this study.[15] The statistical analysis was performed using StataSE v. 16 (StataCorp, USA).

Results

The merged dataset included 26,403 RSAs. A total of 672 patients (2.55%) had multiple diagnosis groups that could not be further stratified and therefore were removed. In 197 patients (0.77% of cohort and 3.93% of deaths), the date

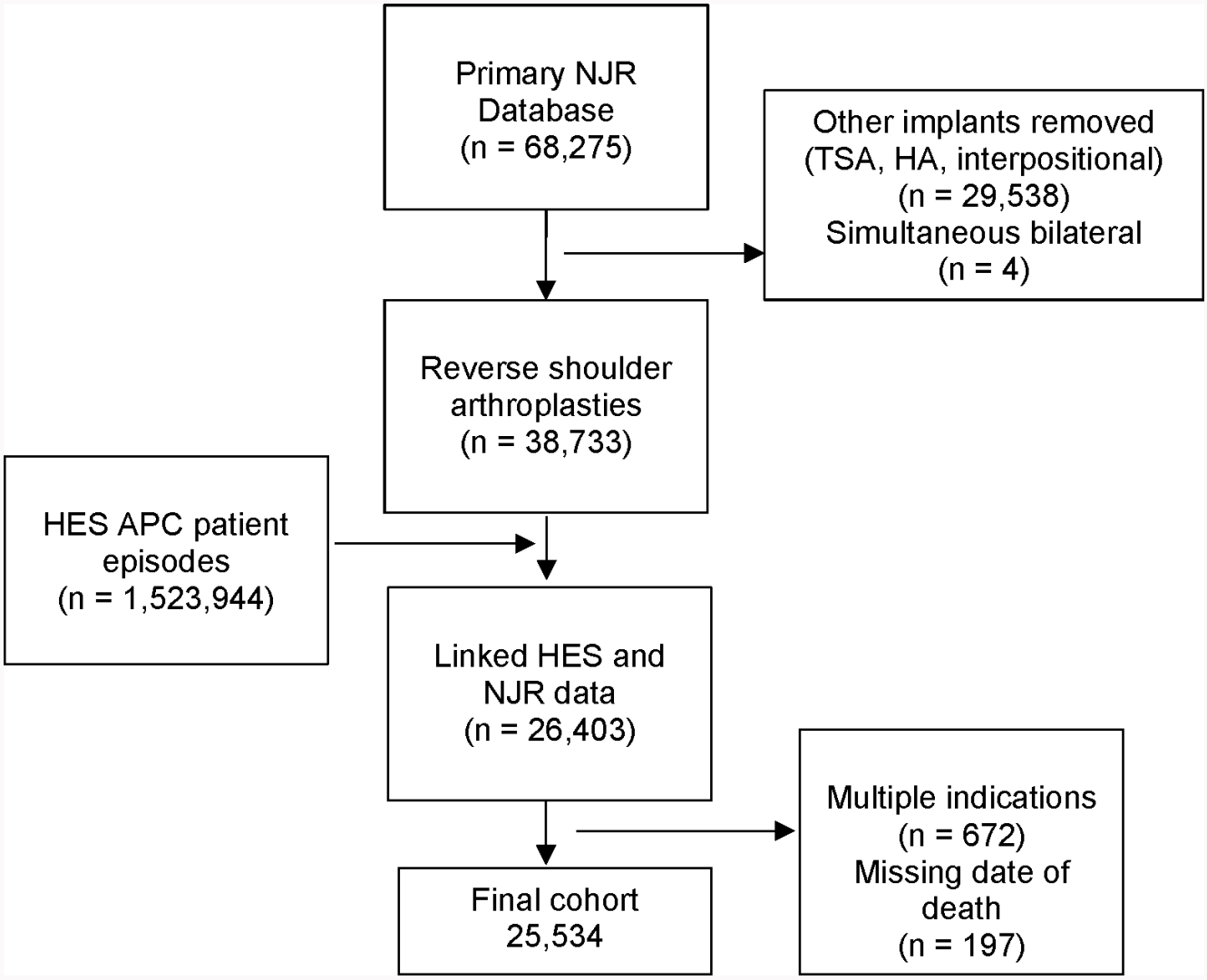

Fig. 1
Study flow diagram. APC, admitted patient care; HA, hemiarthroplasty; HES, Hospital Episode Statistics; NJR, National Joint Registry; TSA, total shoulder arthroplasty.

of death was unable to be obtained from the ONS data. This left 25,534 patients for analysis (Figure 1).

A total of 25,534 RSA patients were available for the analysis of revision, with a mean age of 75.42 years (SD 7.77) in a population that was majority female (72.29%, n = 18,458). The mean age varied by indication, and ranged from 64.34 years in patients with metastasis/malignancy to 76.45 years in OA. All indications had a majority female demographic ranging from 52% in dislocation arthropathy to over 80% in IA, avascular necrosis (AVN), and trauma (Table I). The distribution of patients by age group is presented in Figure 2.

The most common cause of revision in the majority of indications was dislocation/instability; 11% of the revisions were coded as an indication of 'other' or unspecified and 14.5% were coded for multiple indications; therefore, there were a larger number of indications than revision cases. Table II shows the three most common indications for revision by each primary indication.

Survival analysis was completed for the 11 groups. To note, the NJR introduced cuff tear without arthropathy and dislocation arthropathy as an indication in 2018, and therefore there is a maximum of four years of follow-up data. Metastasis or malignancy was added as a diagnosis in 2014 and therefore has a maximum follow-up of eight years (Figure 3).

Table III shows the cumulative revision rate by indication at two-yearly time intervals with 95% CIs.

Cox proportional hazards model was used to assess the effect of indication on revision risk. Given that CTA was the indication RSA was designed for, this was used as the baseline comparator. In both the unadjusted and adjusted model (age and sex) RSA carried out for trauma sequalae had a significantly increased risk of revision ($p \leq 0.001$); the other indications did not show an increased risk of revision (Supplementary Table iii).

The incidence of reoperation in RSA between April 2012 and March 2022 was 1.1% (306 reoperations in 283 patients). Of the 281 patients that had a reoperation, 98 (34.88%) went on to have revision surgery.

Table IV shows the breakdown of the specific reoperations of patients with a specified indication. The most common reoperation experienced across indications was a

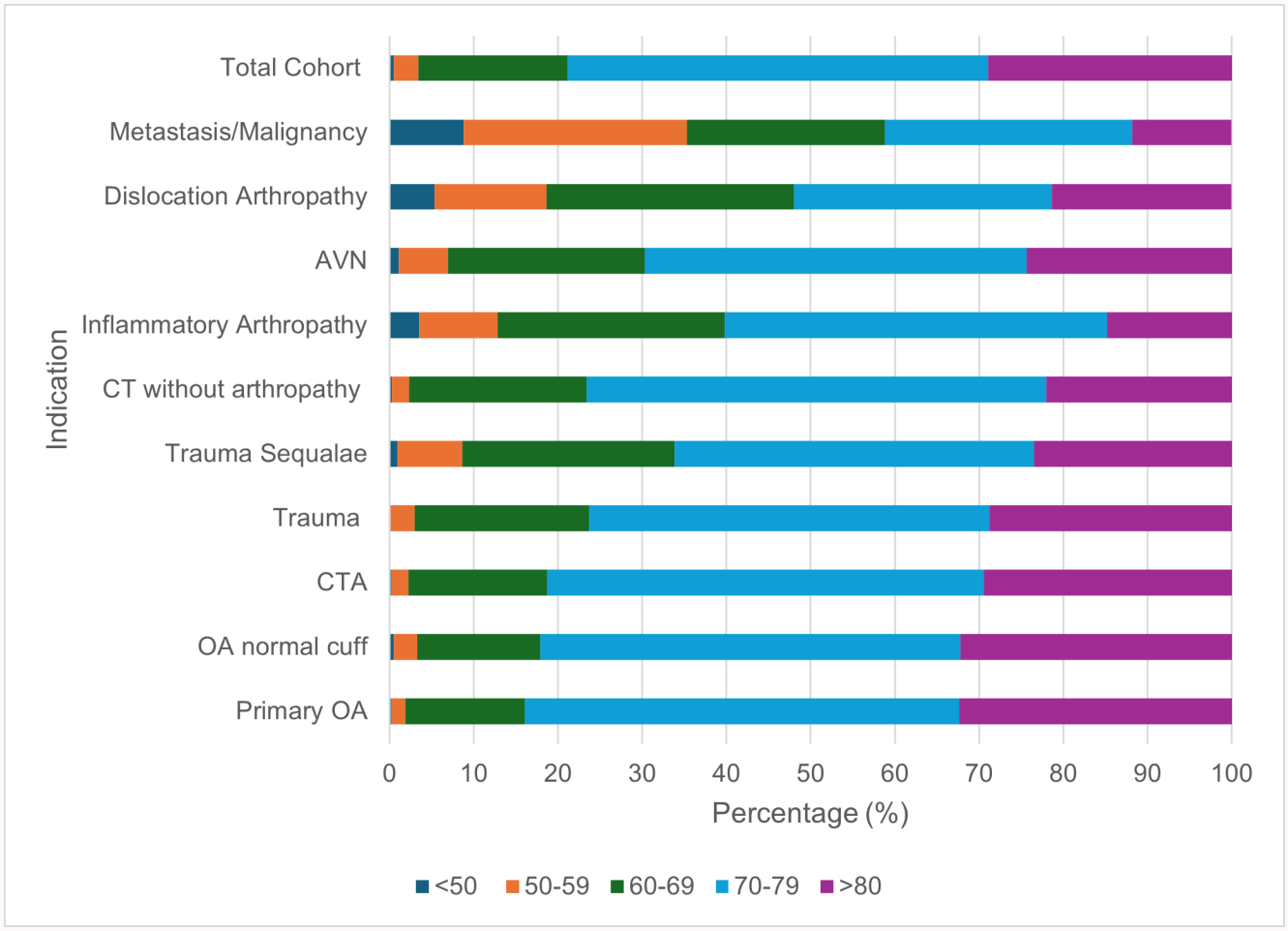

Fig. 2
Age groups by indication. AVN, avascular necrosis; CTA, cuff tear arthropathy; OA, osteoarthritis.

Table I. Demographic data by indication.

Indication	Number of patients (%)	Mean age at primary, yrs (SD)	Sex (% female)
CTA	11,117 (43.54)	75.88 (7.11)	66.95
Primary OA (absent/attenuated/torn cuff)	5,803 (22.73)	76.45 (7.05)	75.81
Trauma	3,646 (14.28)	75.30 (7.89)	80.17
Trauma sequalae	1,923 (7.53)	72.95 (9.01)	78.47
Primary OA normal cuff	1,027 (4.02)	76.14 (7.71)	72.93
Inflammatory arthropathy	601 (2.35)	70.75 (9.87)	81.53
Cuff tear without arthropathy	645 (2.53)	74.42 (7.07)	61.40
AVN	287 (1.12)	73.68 (8.58)	81.88
Other	376 (1.47)	70.47 (13.24)	67.55
Dislocation arthropathy	75 (0.29)	70.06 (12.05)	52.00
Mets or malignancy	34 (0.13)	64.34 (13.30)	61.76
Total	25,534	75.42 (7.77)	72.29

AVN, avascular necrosis; CTA, cuff tear arthropathy; Mets, metastases; OA, osteoarthritis.

Table II. Most common indications for revision.

Indication (n = patients revised)	First revision indication	%	Second revision indication	%	Third revision	%
Primary OA (n = 131)	Infection (n = 38)	29.01	Dislocation/instability (n = 35)	26.72	Periprosthetic fracture (n = 19)	14.50
OA normal cuff (n = 18)	Dislocation/instability (n = 5)	27.78	Periprosthetic fracture (n = 5)	27.78	Infection (n = 2) Aseptic loosening (n = 2)	11.11
CTA (n = 334)	Dislocation/instability (n = 102)	30.54	Infection (n = 98)	29.34	Aseptic loosening (n = 57)	17.06
Trauma (n = 71)	Dislocation/instability (n = 38)	53.52	Infection (n = 17)	23.94	Aseptic loosening (n = 6) Periprosthetic fracture (n = 6)	8.45
Trauma sequelae (n = 118)	Dislocation/instability (n = 60)	50.85	Infection (n = 25)	21.19	Periprosthetic fracture (n = 18)	15.25
CT without arthropathy (n = 18)	Dislocation/instability (n = 8)	44.44	Infection (n = 7)	38.89	Component dissociation (n = 4)	22.22
IA (n = 24)	Dislocation/instability (n = 8)	33.33	Infection (n = 6)	25.00	Aseptic loosening (n = 2) Periprosthetic fracture (n = 2)	8.33
AVN (n = 9)	Dislocation/instability (n = 2)	22.22	Infection (n = 2)	22.22	Aseptic loosening (n = 2)	22.22
Dislocation arthropathy (n = 4)	Impingement (n = 2)	50.00	Dislocation/instability (n = 1)	25.00	Aseptic loosening (n = 1) Periprosthetic fracture (n = 1)	25.00
Mets/malignancy (n = 1)	Infection	100 (n = 1)				

AVN, avascular necrosis; CTA, cuff tear arthropathy; IA, inflammatory arthropathy; Mets, metastases; OA, osteoarthritis.

MUA with or without capsular release (42.03%, n = 124) followed by subacromial decompression (21.02%, n = 62).

Discussion

Data from the NJR demonstrate that despite RSA being designed for CTA, in over 50% of patients in the registry, a RSA was carried out for an indication for which it was not primarily designed. The expansion in use is likely to grow with overall shoulder arthroplasty numbers, which are projected to increase by 234% in England by 2050.[16] RSA has recently been shown to be an acceptable alternative to TSA in those aged over 60 years with OA and an intact cuff.[17] The study by Valsalmis et al[17] showed that at long-term follow-up, RSA had no statistically significant difference in revision rates compared with TSA. The RAPSODI trial, currently in recruitment stages, is a randomized controlled trial (RCT) that is aiming to look at the comparison between RSA and TSA for OA and intact cuff.[18] The PROFHER 2 trial has recently completed recruitment. This three-armed RCT is comparing nonoperative treatment with HA and RSA for three- and four-part proximal humeral fractures, and is likely to improve the quality of evidence that informs the use of RSA in complex proximal humerus fractures.[19]

Historically, RSA was designed for, and has been implanted in, older patients. This study showed that in all indications and in the overall cohort, RSA is most commonly implanted in those aged 70 to 79 years. Despite the majority of RSAs being carried out for those aged 70 to 79 years, over 50% of RSAs were implanted in patients outside of this age bracket. A total of 28.91% patients were aged > 80 years, and with life expectancy > 80 years in many Western countries, as well as an ageing population, the use of RSAs in this population may further increase.[20] Overall, 21.12% of our cohort were under the age of 70 years, and some indications (metastasis/malignancy, dislocation arthropathy, and IA) were in over 10% of patients aged under 60 years. A systematic review of patients aged under 65 years receiving RSA for cuff-deficient shoulders or failed primary arthroplasty has shown reliable clinical improvement following RSA with a revision rate of 7% at four years.[21] A further study looking at patients aged under 65 years found a revision rate of 5.8% at a mean follow-up of 6.3 years.[22] Given the use of the RSA in a younger population for whom it was not primarily designed, and the age-dependent variation in revision rates shown in a HES analysis of shoulder arthroplasty, it is important to consider age and the need for implant longevity in a younger patient.[7]

With the exception of RSA for trauma sequalae, which had a higher revision rate, the revision rates across all the indications for RSA in this NJR study were comparable; this finding persisted when adjusted for age, sex, and comorbidity. Although trauma sequalae only represented 7.53% of cases, the revision rate was 8.08% at seven years, and this was almost double that for CTA (4.05%) and over three times more than OA with a normal cuff (2.34%). The Australian NJR analyzed 47,251 RSAs by indication and reported a higher rate of revision at each timepoint for CTA in comparison with our

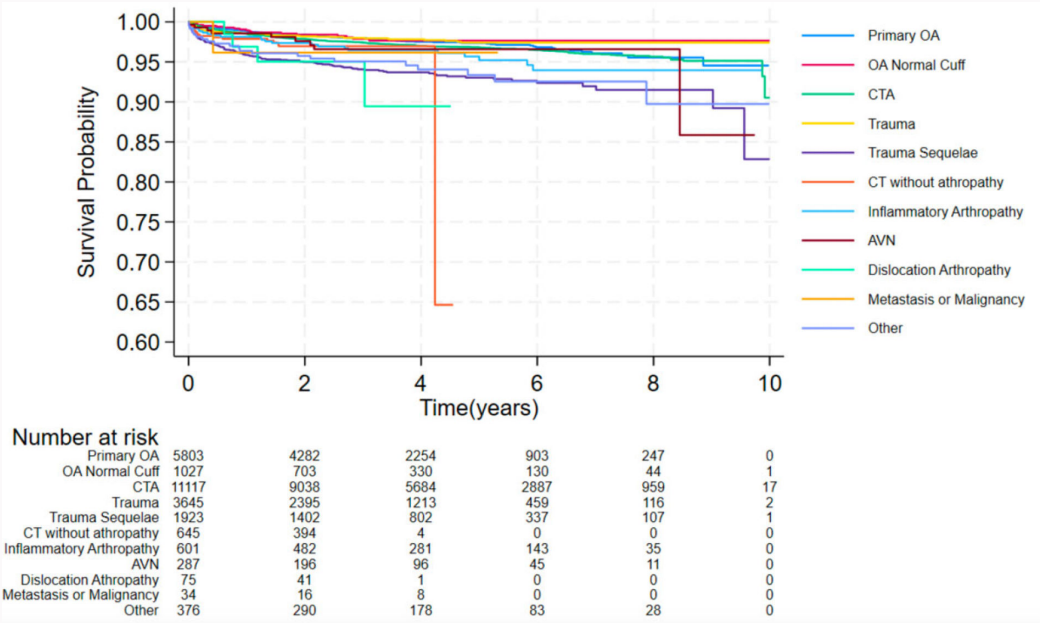

Fig. 3
Kaplan-Meier curve for revision by indication. AVN, avascular necrosis; CTA, cuff tear arthropathy; OA, osteoarthritis.

Table III. Cumulative revision rates by indication, % (95% CI).

Indication	One-year revision	Three-year revision	Five-year revision	Seven-year revision	Nine-year revision
Primary OA	1.21 (0.95 to 1.54)	2.09 (1.72 to 2.54)	2.71 (2.25 to 3.37)	3.89 (3.10 to 4.86)	5.00 (3.62 to 6.88)*
OA normal cuff	1.08 (0.58 to 2.01)	2.10 (1.30 to 3.33)	2.34 (1.46 to 3.74)	2.34 (1.46 to 3.74)*	2.34 (1.46 to 3.74)*
CTA	1.53 (1.31 to 1.78)	2.60 (2.31 to 2.94)	3.21 (2.86 to 3.60)	4.05 (3.59 to 4.58)	4.97 (4.23 to 5.84)
Trauma	1.51 (1.15 to 1.99)	2.07 (1.62 to 2.65)	2.67 (2.07 to 3.43)	2.67 (2.07 to 3.43)	2.67 (2.07 to 3.43)*
Trauma sequelae	4.25 (3.4 to 5.29)	6.05 (5.00 to 7.31)	7.12 (5.90 to 8.59)	8.08 (6.59 to 9.88)	8.67 (6.88 to 10.89)*
CT without arthropathy	2.32 (1.36 to 3.97)	3.23 (2.02 to 5.17)	41.94 (8.1 to 97)*		
Inflammatory arthropathy	1.95 (1.08 to 3.48)	3.64 (2.33 to 5.66)	6.03 (3.89 to 9.28)	6.03 (3.89 to 9.28)*	6.03 (3.89 to 9.28)*
AVN	1.55 (0.58 to 4.08)	3.60 (1.80 to 7.13)*	3.60 (1.80 to 7.13)*	3.60 (1.80 to 7.13)*	14.94 (3.46 to 52.47)*
Dislocation arthropathy	3.05 (0.7 to 1.17)*	5.07 (1.64 to 15.08)*	14.57 (3.94 to 46.04)*		
Mets or malignancy	3.85 (0.06 to 24.31)*	3.85 (0.06 to 24.31)*	3.85 (0.06 to 24.31)*		
Other	3.70 (2.16 to 6.28)	5.06 (3.17 to 8.03)	6.58 (4.23 to 10.17)*	7.47 (4.76 to 11.62)*	9.54 (5.51 to 16.28)*

*Under 250 cases at risk.
AVN, avascular necrosis; CTA, cuff tear arthropathy; OA, osteoarthritis.

study (one year 2.3%, three years 3.6, five years 4.2, seven years 4.6); they similarly found a reduced rate of revision in OA, but an increased rate of revision in fracture, which differed from our results.[3] A study focusing on RSA for trauma by the Nordic Joint Registry found a five-year revision rate of 3.00% (2.00 to 4.50) in 1,523 patients, which is a higher revision rate than our study of 2.67% (2.07 to 3.43), but with the same most common cause for revision or instability.[23] Studies looking at outcomes of RSA for trauma have shown it to be an acceptable treatment option; however, there are limited studies looking at comparative outcomes between RSA for trauma sequalae and other indications.[24,25] It is assumed that these cases are carried out for previous failure of conservative management, development of AVN, or failed operative fixation, which in turn leads to a potentially more difficult salvage arthroplasty procedure. A study by Katthagen et al[26] in 68 patients, comparing primary RSA for acute trauma with RSA for trauma sequalae, showed that primary RSA had better clinical function and significantly lower revision and complication rates. A systematic review by Zumstein et al[27] also

Table IV. Reoperations by indication.

Indication (n = reoperations)	Subacromial decompression, n (%)	Rotator cuff repair, n (%)	Stabilization, n (%)	Relocation, n (%)	MUA with or without capsular release, n (%)	Synovectomy, n (%)	Fracture fixation, n (%)
Primary OA (n = 43)	14 (32.56)	3 (6.98)	2 (4.65)	5 (11.63)	16 (37.21)	0 (0)	3 (6.98)
OA normal cuff (n = 7)	3 (42.86)	1 (14.29)	0 (0)	0 (0)	2 (28.57)	0 (0)	1 (14.29)
CTA (n = 134)	35 (26.12)	6 (4.48)	5 (3.73)	12 (8.96)	57 (42.54)	7 (5.22)	12 (8.96)
Trauma (n = 58)	4 (6.90)	1 (1.72)	2 (3.45)	15 (25.86)	24 (41.38)	0 (0)	12 (20.69)
Trauma sequelae (n = 37)	2 (5.41)	0 (0)	1 (2.70)	7 (18.92)	19 (51.35)	2 (5.41)	6 (16.22)
CT without arthropathy (n = 9)	3 (33.33)	0 (0)	0 (0)	0 (0)	5 (55.56)	0 (0)	1 (11.11)
IA (n = 4)	0 (0)	1 (25.00)	1 (25.00)	1 (25.00)	1 (25.00)	0 (0)	0 (0)
AVN (n = 1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)
Dislocation arthropathy (n = 2)	1 (50.00)	1 (50.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mets/malignancy (n = 0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total (n = 295)	62 (21.02)	13 (4.41)	11 (3.72)	40 (13.56)	124 (42.03)	10 (3.39)	35 (11.86)

AVN, avascular necrosis; CTA, cuff tear arthropathy; IA, inflammatory arthropathy; MUA, manipulation under anaesthesia; OA, osteoarthritis.

highlighted a possible high complications in RSA for fracture sequalae in comparison with other indications, although the sample size was small (41 patients).

The most common cause of revision in all indications was instability/dislocation, except for primary OA, where the most common cause was infection and in dislocation arthropathy, where the most common was impingement. Instability/dislocation is the most common cause of revision and is well reported in various studies as well as in other national joint registries.[3,28] Instability following RSA can be attributed to surgical technique, soft-tissue management, or prosthetic design with reported poor outcomes for conservative management.[29,30] Strategies to improve stability, such as lateralized designs to increase remaining rotator cuff tension and improve impingement-free range of motion (ROM), have shown positive results in terms of stability and ROM, but little translation into improved patient function and outcome scores.[31] Infection is a devastating complication in RSA and is often due to low-virulent pathogens protracting the diagnosis time. There is no agreed guidance on the management of periprosthetic joint infection in RSA, with mixed reports on whether one- or two-stage revision is most appropriate; however, studies have identified strategies to reduce infection risk, such as targeted antibiotic regimes and techniques for skin preparation.[32–35]

The reoperation rate in the cohort was low at 1.1%, with the most common reoperation being MUA with or without capsular release (42.03%). By indication, the rate of complication ranged from 2.67% in RSA for dislocation arthropathy to 0.35% in RSA for AVN. CTA had a complication rate of 1.21% with OA, IA, and AVN having lower rates, and trauma, trauma sequalae, and cuff tear without arthropathy having higher rates. The rates of complications in this study were low compared with a recent systematic review looking at outcomes associated with indication in 3,713 patients. This review quoted reoperation rates from 1.4% in OA to 28% in IA; however, the authors included complications that may have not resulted in operative management, such as acromial/scapular fracture and haematoma.[36]

The limitations of this study include the fact that, when looking at the multiple indications, there is a large variance in sample size between groups, which prevented comparative analysis and matching between multiple groups. This could introduce bias into the results due to confounding factors; however, this study aimed to give a general indication of performance of the RSA, and for more in-depth comparison between certain indications, a matching method would be recommended. Missing data and multiple indications also led to a loss of patients available for analysis. Despite these limitations, this is the largest observational population-based analysis of outcomes of RSA by indication.

In conclusion, this study demonstrated that, based on the largest analysis of RSA across a spectrum of indications, revision rates and secondary surgery rates are broadly similar, with the exception of trauma sequalae. Across the breadth of indications, some of the groups with smaller populations in the registry require further analysis, particularly trauma sequelae, which was found to have a higher revision rate.

Supplementary material

Method for removing multiple indications, and tables of OPCS-4 codes for reoperations, ICD-10 codes for comorbidities, and adjusted and unadjusted cox regression analysis for revision by indication.

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Data sharing

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Ethical review statement

This study used pseudoanonymized, routinely collected data from an established clinical registry, and patient consent is obtained by the National Joint Registry. According to Health Research Authority guidance, ethical approval was not required.

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