Brune *et al. Journal of Orthopaedic Surgery and Research (2024) 19:786*
https://doi.org/10.1186/s13018-024-05285-8

Journal of Orthopaedic Surgery and Research

RESEARCH ARTICLE **Open Access**

Which patient level factors predict persistent pain after reverse total shoulder arthroplasty?

Daniela Brune[1], Steven Z. George[2], Robert R. Edwards[3], Philipp Moroder[4], Markus Scheibel[4,5] and Asimina Lazaridou[1,3*]

Abstract

Background Reverse total shoulder arthroplasty (RTSA) is commonly performed to reduce pain and restore shoulder function in patients with severe shoulder conditions. While most patients experience significant pain relief and functional improvement following surgery, a subset of patients continue to report persistent pain even two years postoperatively. The aim of this study was to identify both modifiable and non-modifiable preoperative factors that contribute to the risk of persistent postsurgical pain after RTSA. By understanding these factors, clinicians can better anticipate which patients are at higher risk and develop tailored preoperative and postoperative pain management strategies to improve overall outcomes.

Methods In this retrospective cohort study, 703 patients with complete data undergoing primary RTSA performed between 2011 and 2022 were analyzed. Persistent postsurgical pain was defined as a pain score ≥ 3 on a numeric rating scale. Multivariable regression models were used to identify patient-related and disease-related predictors of persistent postsurgical pain.

Results The cohort comprised 445 women (63%) and 258 men (37%) with a mean age of 74 ± 8 years at the time of surgery. Persistent postsurgical pain was reported by 18% of patients. Preoperative pain scores averaged 6.0 ± 2.5 on the NRS scale, which decreased to 1.2 ± 1.8 postoperatively. Key predictors included higher preoperative pain levels (β = 0.10, $p < 0.001$), worse preoperative QuickDASH scores (β = 0.09, $p = 0.002$), mild symptoms of anxiety or depression (β = 0.52, $p = 0.001$), prior contralateral TSA surgery (β = 0.34, $p = 0.018$) and greater number of previous ipsilateral shoulder surgeries (β = 0.44, $p < 0.001$). In contrast, patients with rheumatoid arthritis (β = −0.85, $p < 0.001$) or primary osteoarthritis (β = −0.82, $p < 0.001$) experienced lower pain levels.

Conclusion Our study offers important insights into the predictors of persistent postsurgical pain two years after RTSA. Key factors, including higher preoperative pain scores, poor mental health, elevated QuickDASH scores, prior contralateral TSA surgery and a history of prior ipsilateral shoulder surgeries, were identified as significant risk indicators for persistent postsurgical pain.

Keywords Arthroplasty, Replacement, Shoulder, Pain, Postoperative

*Correspondence:
Asimina Lazaridou
asimina.lazaridou@kws.ch
Full list of author information is available at the end of the article

Introduction

Reverse total shoulder arthroplasty (RTSA) is a well-established surgical intervention, primarily indicated for patients with advanced glenohumeral arthritis [1] and massive rotator cuff tears [2]. RTSA has shown substantial growth in recent years. In the United States, the population-adjusted incidence of RTSA increased from 7.3 cases per 100,000 in 2012 to 19.3 cases per 100,000 by 2017, representing nearly a 200% rise in procedures over five years [3]. Similarly, Finland reported a 4,500% increase in RTSA procedures between 2004 and 2015, with the incidence rising from 6 to 15 cases per 100,000 person-years in men and from 11 to 26 cases in women [4]. This significant increase underscores the growing recognition of RTSA as a reliable and effective treatment, aimed at relieving pain, restoring function and improving quality of life for patients [5–7].

While most patients experience significant pain relief and functional improvement following surgery [8–11], approximately 20% continue to experience persistent pain beyond the expected recovery period 1–2 years after shoulder replacement surgery [12–14]. Chronic postsurgical pain (CPSP) is a recognized adverse consequence of surgery and typically refers to pain lasting at least three months after surgery [15, 16]. Understanding the multifactorial nature of CPSP after RTSA is crucial for predicting and managing patient outcomes effectively. Factors, including patient demographics, preoperative pain intensity, psychological factors [17, 18], surgical technique [19], implant design [20] and postoperative rehabilitation all play a role in the development of persistent postsurgical pain. By considering these multifactorial elements comprehensively, surgeons can better identify patients at risk and tailor their management strategies accordingly.

While previous studies have examined factors contributing to residual pain after shoulder joint replacement [12, 14, 18, 21], there is a limited research specifically examining the risk factors associated with pain that persists beyond the one-year follow-up period for RTSA. Understanding patients' pain experiences over the long term could provide valuable insights for improving patient selection, preoperative counseling and setting realistic postoperative expectations. For instance, a study examining outcomes two years after primary RTSA found that 28% of patients reported overall dissatisfaction, while 26% did not experience significant improvements in quality of life [22]. Similarly, a study on patients undergoing hip, knee and shoulder joint arthroplasty revealed that 9.8% to 16.3% experienced high-impact chronic pain, while 21.3% to 39.6% reported bothersome chronic pain within 6 months to 5 years post-operatively [18]. These findings suggest that persistent pain remains a significant issue across various joint replacement procedures, underscoring the need for further investigation into long-term pain outcomes in RTSA patients.

The aim of this study is to identify both modifiable and non-modifiable preoperative patient characteristics that are associated with persistent postsurgical pain in RTSA patients two years following surgery. These findings from this study will contribute to the existing literature by identifying which preoperative factors are associated with an increased risk of persistent postsurgical pain following RTSA and could be used to proactively plan for better postoperative pain management options.

Methods

Design and study overview

This retrospective cohort study analyzed data from a prospectively maintained shoulder arthroplasty registry at a private orthopedic institution [23]. Patients were eligible for inclusion if they underwent primary RTSA and had a minimum of 2 years follow-up. Patients who had undergone revision surgery or had incomplete preoperative baseline data were excluded from the analysis. Additionally, patients with missing postoperative pain assessments were excluded to ensure the accuracy and completeness of pain-related outcome measures.

Data collection in the registry comprised both self-reported information, including sociodemographic characteristics and Patient Reported Outcome Measurements (PROMs), as well as clinical and surgical data extracted from medical records. Data were systematically collected and managed using Research Electronic Data Capture (REDCap) system [24], ensuring secure and standardized handling of patient data. PROMs were administered either electronically or via paper–pencil questionnaires at baseline (up to one day before surgery) and again two years postoperatively.

Outcome measures

The primary outcome of interest was the presence of persistent pain at 2 years postoperatively, assessed using the pain Numeric Rating Scale (NRS) (0 = no pain, 10 = worst pain). Persistent postsurgical pain was defined as an NRS score of 3 or higher. Although the minimally clinically important difference (MCID) for the Visual Analog Scale (VAS) pain score after TSA is 1.4 [25], we opted to use a cut-off of NRS $\geq$ 3. This decision aligns with findings from Simanski et al. (2014) [26] and Fletcher et al. (2015) [27], both of whom identified NRS $\geq$ 3 as a reliable indicator for persistent postsurgical pain. Simanski et al. (2014) found that NRS $\geq$ 3 at one-year post-surgery could be used to identify chronic pain across various surgical disciplines, while Fletcher et al. (2015) demonstrated that NRS ≥ 3 accurately detected moderate to severe persistent postsurgical pain at 12 months, with higher NRS scores correlating with greater functional impairment.

Outcome predictors

Potential predictors of persistent postsurgical pain were examined using various patient-related and disease-related covariates. Patient-related covariates included age at the time of surgery, sex, body mass index (BMI), smoking status (current smoker vs. no smoker), alcohol consumption (never, occasional, daily) and the American Society of Anesthesiologists Physical Status Classification (ASA) [28]. Baseline mental health was assessed using scores from the Anxiety and Depression dimension of the European Quality of Life 5 Dimensions 5 Level (EQ-5D-5L) scale [29], where patients rated their emotional state on a scale from 0 (not anxious or depressed) to 4 (extremely anxious or depressed).

Preoperative PROMs included the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) and the Shoulder Pain and Disability Index (SPADI). The QuickDASH is an abbreviated form of the DASH Outcome Measure, designed to assess physical function and symptoms in individuals with musculoskeletal disorders of the upper limb. The overall score is calculated on a scale from 0 to 100, with 0 representing no disability (full, unrestricted function) and 100 representing the most severe functional impairment possible in the upper extremity [30, 31]. The SPADI [32, 33] is a widely used self-reported questionnaire designed to measure pain and disability associated with shoulder conditions. It consists of 13 items divided into two subscales: a 5-item pain subscale and an 8-item disability subscale. Each item is scored on a scale from 0 to 10, where 0 represents no pain or disability and 10 indicates the worst possible pain or highest level of disability. The scores for each subscale are averaged and then combined to provide a total score out of 100, with higher scores indicating greater levels of pain and disability.

Additionally, the baseline Constant-Murley Score (CMS) was used to evaluate shoulder function. The CMS [34] is a widely used tool for assessing shoulder function in individuals with musculoskeletal disorders. It evaluates four main components: pain, daily activities, range of motion (ROM) and strength. Each section is scored to give a total score between 0 and 100, with higher scores indicating better shoulder function. In this study, only the objective ROM component of the CMS was included, as daily activity measures were already captured using the QuickDASH and SPADI questionnaires. The range of motion (ROM) dimension is scored from 0 to 40 points, with higher scores reflecting better shoulder function.

Covariates

Disease-related covariates included dominance of the affected shoulder, surgery duration in minutes, prior contralateral TSA surgery (bilateral vs. unilateral), surgery admission type (illness or accident), hospitalization days, number of previous ipsilateral shoulder surgeries other than arthroplasty surgeries, primary surgery diagnosis (Cuff Tear Arthropathy (CTA), rheumatoid arthritis, acute or sequelae fracture, primary osteoarthritis, primary humeral head necrosis), humerus fixation (cemented vs. cementless) and additional procedures performed during surgery such as tuberosity remodeling or refixation, biceps tenodesis or tenotomy, muscle transfer, metal removal, bone grafting, osteosynthesis and acromioplasty.

Data management and analysis

Deidentified data were extracted from REDCap for analysis. Continuous variables were summarized as means with standard deviations (SD), while categorical variables were reported as frequencies and percentages. Normality was assessed using a goodness-of-fit test, which indicated that most variables were not normally distributed, leading to the use of nonparametric methods.

Spearman rank correlation was employed to assess relationships between continuous variables and NRS pain levels. For multivariable comparisons, multiple linear regression models were built using ordinary least squares (OLS) with robust standard errors [35] to address potential non-normality and heteroscedasticity. Multicollinearity was evaluated using the variance inflation factor (VIF) with a threshold of 5. All variables were considered eligible for inclusion in the models. Model selection was guided by the coefficient of determination (R^2) and the Akaike Information Criterion (AIC) [36] to identify best-fitting model.

A sensitivity analysis was conducted to validate our findings and assess the potential bias introduced by missing data, since our analysis was restricted to complete cases. We compared the baseline characteristics of patients included in the analysis with those excluded due to missing values on candidate predictors. This comparison was crucial in identifying whether systematic differences existed between the included and excluded groups, as such differences could introduce selection bias, potentially affecting the internal validity and generalizability of the study's findings.

To support the robustness of our results, we also performed multivariable logistic regression as part of our primary analysis, ensuring that the identified predictors remained consistent across models.

Persistent postsurgical pain (NRS pain scores of 3 or higher) was modeled to predict its occurrence two years postoperatively. Patients were dichotomized into two groups based on the presence or absence of persistent postsurgical pain. Comparisons were made using the Wilcoxon rank-sum test (Mann–Whitney *U*-Test) for continuous variables and Fisher's exact test for categorical variables. This approach enabled us to explore the collective impact of multiple predictors on the likelihood of experiencing persistent postsurgical pain, providing a more comprehensive understanding of the relationships between these variables. The model was subsequently rebuilt to compare results and ensure consistency. Statistical analyses were conducted using Stata 18 software [37], with a significance level set at $p < 0.05$ unless otherwise specified.

Results

A total of 703 patients with completed data who underwent primary RTSA between January 2011 and September 2022 were included in the analysis (Fig. 1). The cohort comprised 445 women (63%) and 258 men (37%) with a mean age of 74 ± 8 years at the time of surgery. Preoperative pain scores averaged 6.0 ± 2.5 on the NRS scale, which decreased to 1.2 ± 1.8 postoperatively (Fig. 2).

Persistent postoperative pain, defined as an NRS score of 3 or higher, occurred in 18% of patients at two years. Key preoperative differences between the persistent and non-persistent pain groups are presented in Table 1. Patients with persistent pain had higher BMI (28 ± 5 vs. 26 ± 5 kg/m^2; $p = 0.010$), higher alcohol consumption rates ($p = 0.007$), more frequent preoperative anxiety or depression symptoms ($p = 0.004$) and a greater number of previous ipsilateral shoulder surgeries (0.7 ± 1.1 vs. 0.4 ± 0.7; $p < 0.001$). Preoperative PROMs and pain scores were worse in the persistent pain group, including higher QuickDASH (58 ± 16 vs. 47 ± 18; $p < 0.001$), SPADI (70 ± 18 vs. 61 ± 20; $p < 0.001$) and NRS pain scores (7 ± 2 vs. 6 ± 3; $p < 0.001$). Additionally, they had lower preoperative ROM scores (13 ± 8 vs. 15 ± 8; $p = 0.020$). No significant differences were observed between groups for humeral fixation type, surgery duration or length of hospitalization, but prior contralateral TSA was more common in the persistent pain group (28% vs. 24%; $p = 0.056$). Cuff tear arthropathy (CTA) was the most frequent surgical indication (61%). Persistent pain patients were more likely to have CTA (76% vs. 58%; $p < 0.001$), while primary osteoarthritis was more prevalent in the no-pain group (29% vs. 9%). No significant differences were seen in additional procedures (e.g. tuberosity remodeling, biceps tenodesis), though bone grafting showed a trend towards higher rates in the persistent pain group (11% vs. 5%; $p = 0.062$). The most used implant was the Universe Reverse (66%), followed by Aequalis Reversed (19%) and Ascend Flex Reverse (11%). Other protheses were used less frequently and no significant differences in implant distribution were observed between persistent and non-persistent pain groups ($p = 0.8181$).

A multivariable linear regression model, adjusted for age, sex and ASA classification, identified several

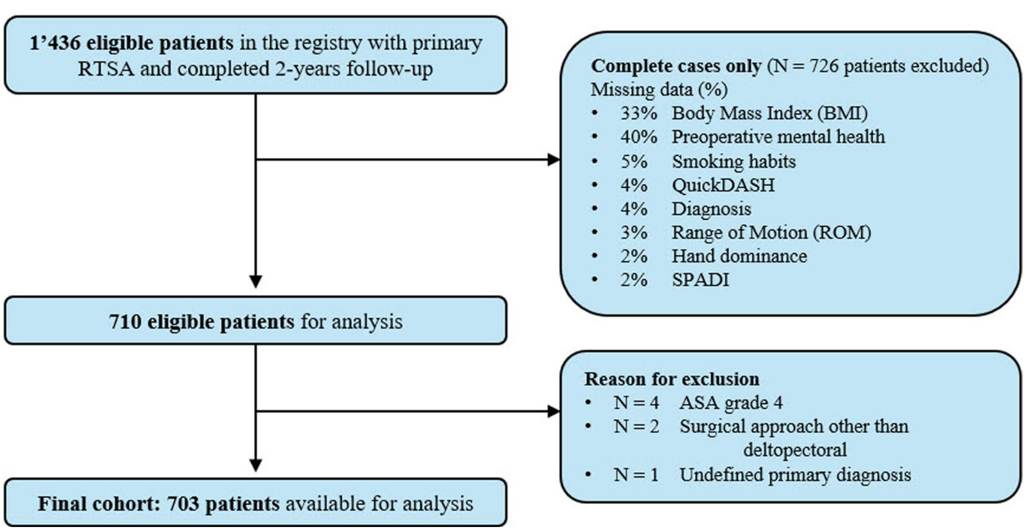

Fig. 1 Flowchart describing sequential patient exclusion to arrive at the cohort sample for analysis. RTSA, Reverse Total Shoulder Arthroplasty; ASA, The American Society of Anesthesiologists physical status classification system; QuickDASH, Quick Disability of the Arm, Shoulder and Hand; SPADI, Shoulder Pain and Disability Index

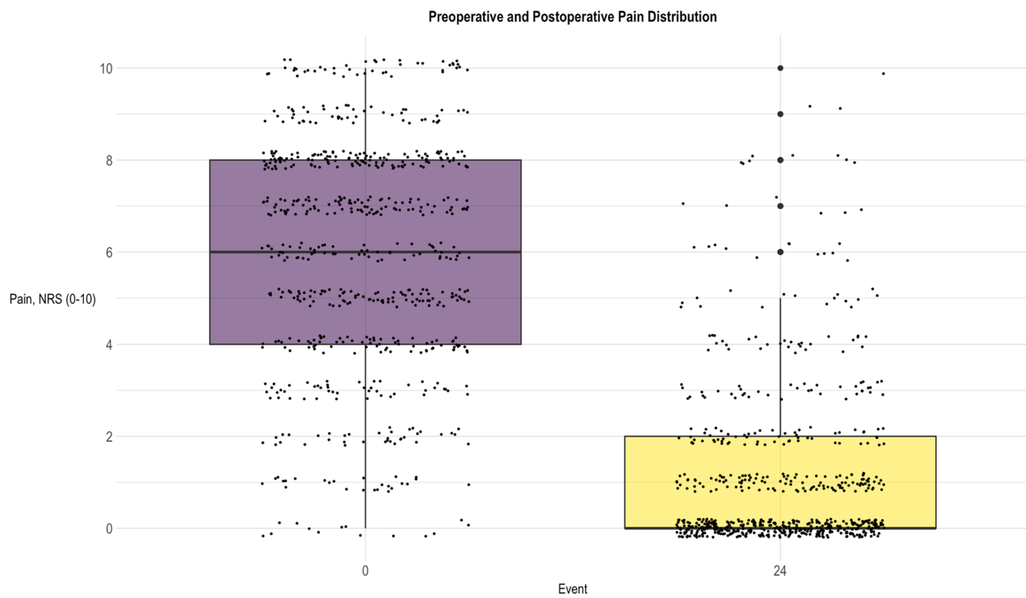

Fig. 2 Boxplot with individual data points (using jittering) for each participant for preoperative and postoperative pain

predictors associated with postoperative pain, explaining 23% of its variance ($R^2 = 0.2283$) (Table 2). Significant predictors included prior contralateral TSA (β = 0.34, $p = 0.018$), higher preoperative NRS pain (β = 0.09, $p = 0.002$), worse preoperative QuickDASH scores (β = 0.03, $p < 0.001$) and a greater number of previous ipsilateral shoulder surgeries (β = 0.44, $p < 0.001$). In contrast, patients with rheumatoid arthritis (β = −0.85, $p < 0.001$) or primary osteoarthritis (β = −0.82, $p < 0.001$) experienced lower pain levels in comparison to patients with CTA. Tuberosity remodeling was also linked to lower postoperative pain (β = −0.34, $p = 0.029$). Mild anxiety or depression symptoms are associated higher pain (β = 0.52, $p = 0.001$), while severe anxiety or depression symptoms were not significant (β = 0.69, $p = 0.334$).

As part of the sensitivity analysis, group comparisons of baseline characteristics between patients included in the analysis and those excluded due to missing values on candidate predictors revealed notable differences. Patients who were excluded had a slightly higher BMI (27 ± 5 vs. 26 ± 5; $p = 0.011$), indicating a trend toward higher BMI among those with incomplete data. Additionally, the duration of surgery was longer for excluded patients (102 ± 29 min vs. 94 ± 30 min; $p < 0.001$). Furthermore, excluded patients reported higher patient-reported outcome measures (PROMs), as reflected by higher QuickDASH scores (55 ± 18 vs. 49 ± 18; $p < 0.001$) and higher SPADI scores (65 ± 19 vs. 62 ± 20; $p = 0.019$).

Logistic regression confirmed similar predictors of persistent pain (Pseudo $R^2 = 0.181$) (Table 3). Key factors that increased the odds of persistent pain included prior contralateral TSA (OR 2.27, $p = 0.002$), a higher number of previous ipsilateral shoulder surgeries (OR 1.61, $p = 0.001$) and elevated preoperative NRS pain scores (OR 1.13, $p = 0.019$). Worse preoperative QuickDASH scores were also linked to increased odds of persistent postsurgical pain (OR 1.03, $p < 0.001$). Patients with primary OA were less likely to experience higher pain levels (OR 0.21, $p < 0.001$). Mild anxiety or depression symptoms increased the likelihood of persistent pain (OR 1.80, $p = 0.013$), whereas severe symptoms did not have any significant impact on the odds of pain persistence (OR 0.85, $p = 0.865$).

Discussion

This study aimed to identify predictors of persistent pain following RTSA in a large cohort of 703 patients. Our main findings indicate that patients with prior contralateral TSA surgery, higher preoperative pain, worse preoperative QuickDASH scores, a history of prior ipsilateral shoulder surgeries and worse mental health states were more likely to experience persistent pain two years postoperatively. Conversely, certain diagnoses, such as primary OA, were associated with lower postoperative pain levels.

Persistent postsurgical pain affected 18% of patients in our cohort, consistent with previous studies, which report a prevalence of 15–20% [12–14]. For example, Puzzitiello et al. (2020) observed that 18.9% of patients continued to experience pain at two years following TSA [13]. They used a NRS cut-off of 2 for defining

Table 1 Patient demographics and cohort description

Parameter	All patients	Persistent pain*		Std. Diff	*p* value
		Yes	No		
Total patients, n (%)	703 (100)	123 (18)	580 (82)		
Age at the time of surgery, years, M (SD)	74 ± 8	73 ± 9	74 ± 8	0.116	0.232
Sex, n (%)				0.038	0.757
Female	445 (63)	76 (62)	369 (64)		
Male	258 (37)	47 (38)	211 (36)		
Body mass index, kg/m^2, M (SD)	26 ± 5	28 ± 5	26 ± 5	0.269	**0.010***
ASA classification, n (%)				0.261	**0.040***
ASA I	13 (2)	1 (1)	12 (2)		
ASA II	373 (53)	54 (44)	319 (55)		
ASA III	317 (45)	68 (55)	249 (43)		
Smoker at the time of surgery, n (%)				0.033	0.729
No	640 (91)	111 (90)	529 (91)		
Yes	63 (9)	12 (10)	51 (9)		
Alcohol consumption at surgery, n (%)				0.306	**0.007****
No	162 (23)	42 (34)	120 (21)		
Occasionally	405 (58)	60 (49)	345 (59)		
Daily	136 (19)	21 (17)	115 (20)		
Preoperative mental health: symptoms of depression and/or anxiety, n (%)				0.316	**0.004****
No	502 (71)	73 (59)	429 (74)		
Mild	191 (27)	48 (39)	143 (25)		
Severe	10 (1)	2 (2)	8 (1)		
Dominant side operated, n (%)				0.022	0.836
No	251 (36)	45 (37)	206 (36)		
Yes	452 (64)	78 (63)	374 (64)		
Prior contralateral TSA surgery, n (%)				0.185	0.056
Unilateral	525 (75)	88 (72)	442 (76)		
Bilateral	178 (25)	35 (28)	138 (24)		
Admission type, n (%)				0.190	0.063
Illness	549 (78)	88 (72)	461 (79)		
Accident	154 (22)	35 (28)	119 (21)		
Insurance, n (%)				0.182	0.072
General	250 (36)	53 (43)	194 (34)		
Private	453 (64)	70 (57)	378 (66)		
Surgery duration, minutes, M (SD)	94 ± 30	95 ± 33	94 ± 29	0.014	0.811
Hospitalization days, M (SD)	6 ± 3	6 ± 5	6 ± 2	0.170	0.088
Number of previous ipsilateral shoulder surgeries, M (SD)	0.4 ± 0.8	0.7 ± 1.1	0.4 ± 0.7	0.356	**< 0.001*****
Diagnosis, n (%)				0.624	**< 0.001*****
Cuff tear arthropathy (CTA)	428 (61)	93 (76)	335 (58)		
Rheumatoid Arthritis	17 (2)	N.A	17 (3)		
Fracture (acute or sequelae)	69 (10)	14 (11)	55 (9)		
Primary osteoarthritis	178 (25)	11 (9)	167 (29)		
Primary Humeral head necrosis	11 (2)	5 (4)	6 (1)		
Preoperative QuickDASH score, M (SD)	49 ± 18	58 ± 16	47 ± 18	0.664	**< 0.001*****
Preoperative NRS pain, M (SD)	6 ± 3	7 ± 2	6 ± 3	0.525	**< 0.001*****
Preoperative SPADI, M (SD)	62 ± 20	70 ± 18	61 ± 20	0.464	**< 0.001*****
Preoperative ROM, M (SD)	15 ± 8	13 ± 8	15 ± 8	0.203	**0.020***
Humeral fixation, n (%)				0.062	0.449

Table 1 (continued)

Parameter	All patients	Persistent pain*		Std. Diff	*p* value
		Yes	No		
Cemented	27 (4)	6 (5)	21 (4)		
Cementless	676 (96)	117 (95)	559 (96)		
Additional procedures (may be several), n (%)					
Tuberosity remodeling or refixation	92 (13)	13 (11)	79 (14)	0.094	0.461
Biceps tenodesis or tenotomy	302 (43)	44 (36)	258 (44)	0.178	0.088
Muscle transfer	10 (1)	1 (1)	9 (2)	0.068	1.000
Metal removal	20 (3)	7 (6)	13 (2)	0.177	0.065
Bone grafting	67 (10)	6 (5)	61 (11)	0.213	0.062
Osteosynthesis	4 (1)	2 (2)	2 (0)	0.130	0.143
Acromioplasty	1 (0)	N.A	1 (0)	0.059	1.000

Group comparison using Two-sample Wilcoxon rank-sum (Mann–Whitney U) test for continuous variables and Fisher' exact test for categorical variables

QuickDASH score ranges from 0 (no disability) to 100 (severe disability)

SPADI score ranges from 0 (no pain | disability) to 100 (severe pain|disability)

ROM score ranges from 0 (worst shoulder function) to 40 (best possible shoulder function)

BMI, Body Mass Index; ASA, American Society of Anesthesiologists Physical Status Classification; TSA, Total Shoulder Arthroplasty; NRS, numeric rating scale; QuickDASH, Quick Disability of the Arm, Shoulder and Hand; SPADI, Shoulder Pain and Disability Index; ROM, Range of Motion; RTSA, Reverse Total Shoulder Arthroplasty

p-value in bold are statistically significant (*$p<0.05$, **$p<0.01$, ***$p<0.001$)

*Persistent pain was defined with a score of 3 or higher on the pain Numeric Rating Scale (NRS) two years after RTSA (0 = no pain, 10 = worst pain)

persistent pain, while we applied a cut-off of 3. There is evidence suggesting that using a cut-off of 3 may overestimate pain severity in certain subgroups. Boonstra et al. (2016) proposed alternative NRS cut-off points for chronic musculoskeletal pain, suggesting that scores of 4 or 5 indicate mild pain in high catastrophizing individuals but moderate pain in those with low catastrophizing tendencies [38]. While catastrophizing wasn't directly assessed in our cohort, our findings regarding preoperative mental health status align with the broader literature that indicates a strong link between preoperative psychological state and persistent pain after joint arthroplasty [39–42]. For instance, patients with diagnosed mental health conditions such as anxiety or depression are more likely to experience persistent postoperative pain and worse postoperative results following TSA compared to those without such mental conditions [43, 44]. This emphasizes the importance of preoperative mental health assessments to identify at-risk patients and provide tailored interventions that may mitigate the development of persistent pain.

A higher preoperative QuickDASH score has been identified as a strong indicator for persistent postsurgical pain. Studies consistently demonstrate that QuickDASH scores are heavily influenced by pain intensity, with higher pain levels leading to proportionally higher disability scores [45]. In our study, baseline QuickDASH scores differed by 11 points between patients with and without persistent pain, surpassing the Minimal Clinically Important Change (MCIC) of 8 points for patients with shoulder pain [45]. This underscores that the observed difference is not only statistically significant but also clinically relevant. From a clinical perspective, high preoperative disability levels reflected by QuickDASH scores should be considered an early marker for patients at increased risk of long-term postoperative pain.

Interestingly, smoking and BMI did not emerge as significant predictors of persistent postsurgical pain in our cohort, despite existing literature highlighting their associations with persistent pain following musculoskeletal surgeries. Several studies have demonstrated that smoking is a predictor of persistent pain following musculoskeletal surgeries and associated with increased rates of persistent pain due to its detrimental effects on tissue healing and inflammation [1, 46–48]. In a recent literature review, smoking [48] emerged as a strong predictor for postoperative pain in RTSA patients. Another study found that smokers were 2.22 times more likely to experience persistent postoperative pain following hip arthroscopy for Femoroacetabular Impingement [46] and that smoking increases the risk of developing chronic neuropathic pain following lower limb trauma surgeries [49]. Similarly, higher BMI has consistently been linked to higher risk of persistent postsurgical pain, particularly in musculoskeletal surgeries [18, 46, 48, 50, 51]. However, some studies indicate that obese patients may still

Table 2 Multiple linear regression model

Predictor	β [95% CI]	Robust SD	*p* value
Age	− 0.01 [− 0.03–0.01]	0.01	0.311
Male sex	0.16 [− 0.10–0.42]	0.13	0.238
ASA classification			
ASA I	[Reference]		
ASA II	0.07 [− 0.58–0.71]	0.33	0.841
ASA III	0.34 [− 0.23–1.09]	0.33	0.199
Prior contralateral TSA	0.34 [0.06–0.63]	0.14	**0.018***
Preoperative NRS pain (NRS 0–10)	0.09 [0.03–0.14]	0.03	**0.002****
Preoperative QuickDASH score (0–100)	0.03 [0.02–0.03]	0.0	**< 0.001*****
No. of previous ipsilateral shoulder surgeries	0.44 [0.23–0.65]	0.11	**< 0.001*****
Diagnosis			
Cuff Tear arthropathy (CTA)	[Reference]		
Rheumatoid arthritis	− 0.85 [− 1.35–− 0.36]	0.25	**< 0.001*****
Fracture (acute or sequelae)	− 0.35 [− 0.86–0.16]	0.26	0.172
Primary osteoarthritis	− 0.82 [− 1.07–− 0.57]	0.13	**< 0.001*****
Primary humeral head necrosis	0.61 [− 0.80–2.02]	0.72	0.397
Tuberosity remodeling or refixation	− 0.34 [− 0.65–− 0.04]	0.16	**0.029***
Preoperative mental health: symptoms of depression and/or anxiety			
No	[Reference]		
Mild	0.52 [0.20–0.84]	0.16	**0.001****
Severe	0.69 [− 0.71–2.08]	0.71	0.334

N = 703; R^2: 0.2283

Model adjusted for age, sex and ASA classification

QuickDASH Score: 0 = no disability, 100 = severe disability

NRS pain: 0 = no pain, 10 = worst pain

Abbreviations: ASA, American Society of Anesthesiologists Physical Status Classification; TSA, Total Shoulder Arthroplasty; NRS, numeric rating scale; QuickDASH, Quick Disability of the Arm, Shoulder and Hand

p-value in bold are statistically significant (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$)

experience significant improvements in pain post-surgery, although with slower recovery rates and higher risk of complications [50].

In our cohort, patients who underwent prior contralateral TSA were at a higher risk of developing persistent postsurgical pain compared to those with primary unilateral TSA. While recent reviews [8, 52, 53] highlight that bilateral shoulder arthroplasty generally improves patient's functional outcomes, such as range of motion (ROM) and strength and yields high satisfaction rates, our findings suggest it is also a risk factor for persistent pain. This may stem from the cumulative surgical burden on both shoulders and the possibility of incomplete recovery from the first procedure before undergoing the second, potentially contributing to central pain sensitization. Moreover, the anticipation of a second surgery after a painful recovery from the first could exacerbate anxiety and amplify pain perception. This also aligns with the observed association between a higher number of prior ipsilateral shoulder surgeries and increased postoperative pain levels in our cohort, consistent with other literature [12, 54] demonstrating worse outcomes in patients undergoing multiple shoulder procedures.

Primary osteoarthritis (OA) emerged as a significant factor reducing persistent pain, as well as Rheumatoid Arthritis (RA). According to the literature, treatment of glenohumeral osteoarthritis using RTSA has been an effective method assisting in regaining superior functional outcomes when compared to rotator cuff tear arthropathy or/and massive rotator cuff tear [55, 56]. As for rheumatoid arthritis, patients benefit from TSA due to its ability to alleviate joint pain and improve shoulder function by addressing both the inflammatory and mechanical components of the disease [20]. TSA has been shown to be highly effective in reducing pain and improving the quality of life in patients suffering from advanced rheumatoid arthritis [57, 58]. These findings can be explained by the fact that OA and RA are often managed separately through effective pharmacologic treatments, such as nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroids, and disease-modifying

Table 3 Multiple logistic regression model

Predictor	OR [95% CI]	Robust SD	*p* value
Age	0.99 [0.96–1.02]	0.02	0.424
Male sex	1.54 [0.95–2.49]	0.38	0.081
ASA			
ASA I	[Reference]		
ASA II	1.54 [0.27–8.76]	1.37	0.625
ASA III	2.69 [0.47–15.40]	2.39	0.267
Prior contralateral TSA	2.27 [1.36–3.78]	0.59	**0.002****
Preoperative NRS pain (NRS 0–10)	1.13 [1.02–1.26]	0.06	**0.019***
Preoperative QuickDASH score (0–100)	1.03 [1.02–1.05]	0.01	**< 0.001*****
No. of previous ipsilateral shoulder surgeries	1.61 [1.22–2.13]	0.23	**0.001****
Diagnosis			
Cuff tear arthropathy (CTA)	[Reference]		
Rheumatoid arthritis	[empty]		
Fracture (acute or sequelae)	0.74 [0.33–1.65]	0.30	0.459
Primary osteoarthritis	0.21 [0.10–0.42]	0.07	**< 0.001*****
Primary humeral head necrosis	2.01 [0.47–8.57]	1.49	0.347
Anxious or depressed			
No	[Reference]		
Mild	1.80 [1.13–2.86]	0.43	**0.013***
Severe	0.85 [0.13–5.45]	0.81	0.865

N = 686; McFadden's R^2: 0.181

Model adjusted for age, sex and ASA classification

QuickDASH Score: 0 = no disability, 100 = severe disability

NRS pain: 0 = no pain, 10 = worst pain

ASA, American Society of Anesthesiologists Physical Status Classification; TSA, Total Shoulder Arthroplasty; NRS, numeric rating scale; QuickDASH, Quick Disability of the Arm, Shoulder and Hand

p-value in bold are statistically significant (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$)

antirheumatic drugs (DMARDs) for RA, which help control inflammation and alleviate symptoms [59]. Additionally, patients with OA and RA may be more likely to adhere to rehabilitation programs post-surgery, as these conditions tend to be monitored closely by multidisciplinary teams, including physical therapists and rheumatologists, further enhancing recovery and functional outcomes [60].

Despite the strengths of our study, several limitations should be acknowledged. First, the cohort of this study may limit the generalizability of the findings, as it was conducted in a single private orthopedic center and thus representing a specific demographic population and clinical setting. Additionally, we did not account for all possible factors related to persistent postsurgical pain. For example, pain catastrophizing, religious beliefs, sleep patterns, other psychological factors and comorbidities were not assessed as part of this study. Our model explained only 23% of the variance in persistent postsurgical pain, suggesting that other unmeasured factors, such as genetic predispositions or environmental influences, may play a significant role. This underscores the complexity of persistent postsurgical pain and the need for further research to better understand its underlying mechanisms.

Another limitation of our study is the reliance on complete case analysis, which led to the exclusion of patients with missing data on candidate predictors. This approach may introduce selection bias, as excluded patients were found to have significantly different baseline characteristics, such as higher BMI, longer surgery duration, and worse functional scores. These systematic differences could affect the generalizability of our findings, as the included sample may not fully represent the entire population undergoing similar procedures.

Moreover, our reliance on self-reported measures introduces the potential for response bias and our use of the NRS to assess pain may not fully capture the multidimensional nature of persistent postsurgical pain. More comprehensive instruments, such as the Brief Pain Inventory [61], might provide a more nuanced understanding of persistent pain experiences. Additionally, anxiety and depression were assessed using a single question from the EQ-5D-5L, which may not fully reflect the complexity of these psychological factors. Future studies should consider using more detailed assessments to better capture the relationship between mental health and postoperative pain.

Conclusion

In conclusion, our large cohort study offers important insights into the predictors of persistent postsurgical pain two years after RTSA. Key factors, including higher preoperative pain scores, poor mental health, elevated QuickDASH scores, prior contralateral TSA surgery and a history of prior ipsilateral shoulder surgeries, were identified as significant risk indicators for persistent postsurgical pain. These findings provide a foundation for more refined and personalized preoperative evaluations, enabling clinicians to better identify patients at higher risk and implement targeted strategies to mitigate long-term pain outcomes. By improving patient selection and optimizing management, our study contributes to enhancing the overall success of RTSA and postoperative quality of life.

While our study contributes to understanding the complexity of pain outcomes following RTSA, further research is essential to explore additional unexplored factors that may play a role in persistent postsurgical pain. Future studies should also investigate the effectiveness of tailored interventions, such as mental health support or enhanced pain management protocols, in improving long-term postoperative outcomes. Addressing these gaps will be crucial in optimizing patient care and further reducing the incidence of persistent pain after RTSA.

Acknowledgements
We thank Tim Schneller and Beatrice Weber for their contributions to data collection in the Shoulder Arthroplasty Registry.

Author contributions
Conceptualization, A.L. and M.S.; methodology, A.L.; software, D.B.; validation, A.L., R.E., S.G., P.M.; ressources, A.L.; writing—original draft presentation, D.B.; writing—review and editing, A.L., S.G., R.E., D.B.; supervision, A.L. All authors reviewd the manuscript. All authors reviewd the manuscript.

Funding
Not Applicable.

Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This observational study was approved by the Ethical Committee of Canton Zürich (KEK-ZH-Nr. PB_2023-00002). All patients provided written informed consent for the use of their clinical data for research purposes. This work was performed at Schulthess Clinic in Zürich, Switzerland.

Competing interests
The institution of S.G. (Duke University) has received funding from NIH/NIAMS (AR081796) to study post-operative pain following total shoulder arthroplasty. The institution of MS and PM (Schulthess Clinic) is involved in sponsored clinical research with Arthrex Inc. and Tornier Inc. (Stryker Corporation). to conduct a multi-center registry for total shoulder arthroplasty. P.M. designs arthroplasties for Arthrex Inc. and Medacta Corporate. M.S. ist consultant for Tornier Inc. (Stryker Corporation).

Author details
[1]Teaching, Research and Development Upper Extremities & Hand, Schulthess Clinic, Lengghalde 2, 8008 Zurich, Switzerland. [2]Departments of Orthopedic Surgery and Population Health Sciences, Duke School of Medicine, Duke Clinical Research Institute, 300 W. Morgan Street, Durham, NC 27701, USA. [3]Department of Anesthesiology, Brigham & Women's Hospital and Harvard Medical School, 75 Francis Street, Boston, MA 02115, USA. [4]Department for Shoulder and Elbow Surgery, Schulthess Clinic, Lengghalde 2, 8008 Zurich, Switzerland. [5]Center for Musculoskeletal Surgery, Charité-Universitaetsmedizin, Luisenstrasse 64, 10117 Berlin, Germany.

Received: 2 October 2024 Accepted: 15 November 2024
Published online: 22 November 2024

References

1. Samuelsen BT, Wagner ER, Houdek MT, Elhassan BT, Sánchez-Sotelo J, Cofield R, et al. Primary reverse shoulder arthroplasty in patients aged 65 years or younger. J Shoulder Elbow Surg. 2017;26(1):e13–7.
2. Guery J, Favard L, Sirveaux F, Oudet D, Mole D, Walch G. Reverse total shoulder arthroplasty: survivorship analysis of eighty replacements followed for five to ten years. JBJS. 2006;88(8):1742–7.
3. Best MJ, Aziz KT, Wilckens JH, McFarland EG, Srikumaran U. Increasing incidence of primary reverse and anatomic total shoulder arthroplasty in the United States. J Shoulder Elbow Surg. 2021;30(5):1159–66.
4. Harjula JNE, Paloneva J, Haapakoski J, Kukkonen J, Äärimaa V, Honkanen P, et al. Increasing incidence of primary shoulder arthroplasty in Finland—a nationwide registry study. BMC Musculoskelet Disord. 2018;19(1):245.
5. Ogrodzka-Ciechanowicz K, Kurzeja P, Sorysz T. Functional assessment and quality of life of patients after reverse total shoulder arthroplasty in the late follow-up period. J Back Musculoskelet Rehabil. 2023.
6. Kolade O, Ghosh N, Buchalter D, Rosenthal Y, Zuckerman JD, Virk MS. Patterns of limitations in activities of daily living, sleep, and pain in the early postoperative period following total shoulder arthroplasty: a prospective study. JSES Int. 2023;7(1):16–20.
7. Galvin JW, Kim R, Ment A, Durso J, Joslin PMN, Lemos JL, et al. Outcomes and complications of primary reverse shoulder arthroplasty with minimum of 2 years' follow-up: a systematic review and meta-analysis. J Shoulder Elbow Surg. 2022;31(11):e534–44.
8. Bedeir YH, Gawish HM, Grawe BM. Outcomes of reverse total shoulder arthroplasty in patients 60 years of age or younger: a systematic review. J Hand Surg. 2020;45(3):254.
9. Burden EG, Batten TJ, Smith CD, Evans JP. Reverse total shoulder arthroplasty. Bone Joint J. 2021;103-B(5):813–21.
10. Doyle TR, Downey S, Hurley ET, Klifto C, Mullett H, Denard PJ, et al. Midterm outcomes of primary reverse shoulder arthroplasty: a systematic review of studies with minimum 5-year follow-up. JSES Rev Rep Tech. 2024;4(1):1–7.
11. Franceschetti E, Gregori P, Giovannetti de Sanctis E, Palumbo A, Paciotti M, Maffulli N, et al. Return to sport after total shoulder arthroplasty and hemiarthroplasty: a systematic review. Sports Med Arthrosc Rev. 2023;31(1):27–32.
12. Bjørnholdt KT, Brandsborg B, Søballe K, Nikolajsen L. Persistent pain is common 1–2 years after shoulder replacement. Acta Orthop. 2015;86(1):71–7.
13. Puzzitiello RN, Menendez ME, Moverman MA, Mahendraraj KA, Jawa A. Prevalence and predictors of persistent pain 2 years after total shoulder arthroplasty. Semin Arthroplast JSES. 2021;31(1):23–9.
14. Solberg MJ, Alqueza AB, Hunt TJ, Higgins LD. Predicting 1-year postoperative visual analog scale pain scores and American shoulder

and elbow surgeons function scores in total and reverse total shoulder arthroplasty. Am J Orthop. 2017;46(6):E358–65.
15. Bruce J, Quinlan J. Chronic post surgical pain. Rev Pain. 2011;5(3):23–9.
16. Visser EJ. Chronic post-surgical pain: Epidemiology and clinical implications for acute pain management. Acute Pain. 2006;8(2):73–81.
17. George SZ, Bolognesi MP, Ryan SP, Horn ME. Sleep disturbance, dyspnea, and anxiety following total joint arthroplasty: an observational study. J Orthop Surg Res. 2022;17(1):396.
18. George SZ, Bolognesi MP, Bhavsar NA, Penrose CT, Horn ME. Chronic pain prevalence and factors associated with high impact chronic pain following total joint arthroplasty: an observational study. J Pain. 2022;23(3):450–8.
19. Cerciello S, Monk AP, Visonà E, Carbone S, Edwards TB, Maffulli N, et al. The influence of critical shoulder angle on secondary rotator cuff insufficiency following shoulder arthroplasty. Arch Orthop Trauma Surg. 2017;137(7):913–8.
20. Khan WS, Longo UG, Ahrens PM, Denaro V, Maffulli N. A systematic review of the reverse shoulder replacement in rotator cuff arthropathy, rotator cuff tears, and rheumatoid arthritis. Sports Med Arthrosc Rev. 2011;19(4):366–79.
21. Broekman MM, Brinkman N, Swanson D, Ring D, van den Bekerom M, Jawa A. Variations in 1-year trajectories of levels of pain and capability after shoulder arthroplasty are associated with baseline mental health. Clin Orthop Relat Res. 2024;482(3):514–22.
22. Rauck RC, Ruzbarsky JJ, Swarup I, Gruskay J, Dines JS, Warren RF, et al. Predictors of patient satisfaction after reverse shoulder arthroplasty. J Shoulder Elbow Surg. 2020;29(3):e67–74.
23. Marzel A, Schwyzer HK, Kolling C, Moro F, Flury M, Glanzmann MC, et al. The Schulthess local shoulder arthroplasty registry (SAR): cohort profile. BMJ Open. 2020;10(11):e040591.
24. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377–81.
25. Tashjian RZ, Hung M, Keener JD, Bowen RC, McAllister J, Chen W, et al. Determining the minimal clinically important difference for the American shoulder and elbow surgeons score, simple shoulder test, and visual analog scale (VAS) measuring pain after shoulder arthroplasty. J Shoulder Elbow Surg. 2017;26(1):144–8.
26. Simanski CJP, Althaus A, Hoederath S, Kreutz KW, Hoederath P, Lefering R, et al. Incidence of chronic postsurgical pain (CPSP) after general surgery. Pain Med. 2014;15(7):1222–9.
27 Fletcher D, Stamer UM, Pogatzki-Zahn E, Zaslansky R, Tanase NV, Perruchoud C, et al. Chronic postsurgical pain in Europe: an observational study. Eur J Anaesthesiol EJA. 2015;32(10):725–34.
28. Doyle DJ, Hendrix JM, Garmon EH. American society of anesthesiologists classification. StatPearls. Treasure Island (FL) ineligible companies. Disclosure: Joseph Maxwell Hendrix declares no relevant financial relationships with ineligible companies. Disclosure: Emily Garmon declares no relevant financial relationships with ineligible companies.: StatPearls Publishing Copyright© 2024, StatPearls Publishing LLC.; 2024.
29. Feng Y-S, Kohlmann T, Janssen MF, Buchholz I. Psychometric properties of the EQ-5D-5L: a systematic review of the literature. Qual Life Res. 2021;30(3):647–73.
30. Beaton DE, Wright JG, Katz JN, Group TUEC. Development of the QuickDASH: comparison of three item-reduction approaches. JBJS. 2005;87(5):1038–46.
31. Gummesson C, Ward MM, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (Quick DASH): validity and reliability based on responses within the full-length DASH. BMC Musculoskelet Disord. 2006;7(1):44.
32. Angst F, Goldhahn J, Pap G, Mannion AF, Roach KE, Siebertz D, et al. Cross-cultural adaptation, reliability and validity of the German shoulder pain and disability index (SPADI). Rheumatology. 2006;46(1):87–92.
33. Breckenridge JD, McAuley JH. Shoulder pain and disability index (SPADI). J Physiother. 2011;57(3):197.
34. Vrotsou K, Ávila M, Machón M, Mateo-Abad M, Pardo Y, Garin O, et al. Constant-Murley Score: systematic review and standardized evaluation in different shoulder pathologies. Qual Life Res. 2018;27(9):2217–26.
35. Mansournia MA, Nazemipour M, Naimi AI, Collins GS, Campbell MJ. Reflection on modern methods: demystifying robust standard errors for epidemiologists. Int J Epidemiol. 2021;50(1):346–51.
36. Kuha J. AIC and BIC: comparisons of assumptions and performance. Sociol Methods Res. 2004;33(2):188–229.
37. StataCorp. Stata Satistical Software: Release 18. . College Station, TX: StataCorp LLC. 2023.
38. Boonstra AM, Stewart RE, Köke AJ, Oosterwijk RF, Swaan JL, Schreurs KM, et al. Cut-off points for mild, moderate, and severe pain on the numeric rating scale for pain in patients with chronic musculoskeletal pain: variability and influence of sex and catastrophizing. Front Psychol. 2016;7:1466.
39. Hardy A, Sandiford MH, Menigaux C, Bauer T, Klouche S, Hardy P. Pain catastrophizing and pre-operative psychological state are predictive of chronic pain after joint arthroplasty of the hip, knee or shoulder: results of a prospective, comparative study at one year follow-up. Int Orthop. 2022;46(11):2461–9.
40. Colasanti CA, Lin CC, Anil U, Simovitch RW, Virk MS, Zuckerman JD. Impact of mental health on outcomes after total shoulder arthroplasty. J Shoulder Elbow Surg. 2023;32(5):980–90.
41. Vajapey SP, Cvetanovich GL, Bishop JY, Neviaser AS. Psychosocial factors affecting outcomes after shoulder arthroplasty: a systematic review. J Shoulder Elbow Surg. 2020;29(5):e175–84.
42. Wong SE, Colley AK, Pitcher AA, Zhang AL, Ma CB, Feeley BT. Mental health, preoperative disability, and postoperative outcomes in patients undergoing shoulder arthroplasty. J Shoulder Elbow Surg. 2018;27(9):1580–7.
43. Moore AR, Brolin TJ, Smith RA, Azar FM, Throckmorton TW. Outcomes after primary reverse total shoulder arthroplasty in patients with comorbid anxiety and depressive disorders: a retrospective cohort study. Curr Orthop Pract. 2021;32(1):37–42.
44. Werner BC, Wong AC, Chang B, Craig EV, Dines DM, Warren RF, et al. Depression and patient-reported outcomes following total shoulder arthroplasty. JBJS. 2017;99(8):688–95.
45. Mintken PE, Glynn P, Cleland JA. Psychometric properties of the shortened disabilities of the arm, shoulder, and hand questionnaire (QuickDASH) and numeric pain rating scale in patients with shoulder pain. J Shoulder Elbow Surg. 2009;18(6):920–6.
46. Burn E, Edwards CJ, Murray DW, Silman A, Cooper C, Arden NK, et al. The impact of BMI and smoking on risk of revision following knee and hip replacement surgery: evidence from routinely collected data. Osteoarthr Cartil. 2019;27(9):1294–300.
47. Stone AV, Malloy P, Neal WH, Beck E, Waterman BR, Bush-Joseph CA, et al. Predictors of persistent postoperative pain at minimum two-years after arthroscopic treatment of femoroacetabular impingement. Orthop J Sports Med. 2019;7(3_suppl2):2325967119S00201.
48. Waheed I, Ediripolage F, Alvi I, Haider JM. Preoperative risk factors for pain after reverse total shoulder arthroplasty: a systematic review. Cureus. 2024;16(5):e60041.
49. Keene DJ, Knight R, Bruce J, Dutton SJ, Tutton E, Achten J, et al. Chronic pain with neuropathic characteristics after surgery for major trauma to the lower limb: prevalence, predictors, and association with pain severity, disability, and quality of life in the UK WHiST trial. Bone Joint J. 2021;103-B(6):1047–54.
50. Katayama ES, Durisek GR, Bustamante GC, Barry LW, Wilson S, Barnett JS, et al. The role of body mass index in survivorship and clinical outcomes in total shoulder arthroplasty. J Shoulder Elbow Surg. 2024;33(9):1980–9.
51. Eichinger JK, Rao MV, Lin JJ, Goodloe JB, Kothandaraman V, Barfield WR, et al. The effect of body mass index on internal rotation and function following anatomic and reverse total shoulder arthroplasty. J Shoulder Elbow Surg. 2021;30(2):265–72.
52. Polascik BA, Chopra A, Hurley ET, Levin JM, Rodriguez K, Stauffer TP, et al. Outcomes after bilateral shoulder arthroplasty: a systematic review. J Shoulder Elbow Surg. 2023;32(4):861–71.
53. Smith JH, Houck DA, Hart JA, Bravman JT, Frank RM, Vidal AF, et al. Bilateral total shoulder arthroplasty: a systematic review of clinical outcomes. Shoulder Elbow. 2021;13(4):402–15.
54. Parsons M, Routman HD, Roche CP, Friedman RJ. Patient-reported outcomes of reverse total shoulder arthroplasty: a comparative risk factor analysis of improved versus unimproved cases. JSES Open Access. 2019;3(3):174–8.

55 Testa EJ, Glass E, Ames A, Swanson DP, Polisetty TS, Cannon DJ, et al. Indication matters: effect of indication on clinical outcome following reverse total shoulder arthroplasty-a multicenter study. J Shoulder Elbow Surg. 2023;33:1235.
56. Imiolczyk JP, Krukenberg A, Mansat P, Bartsch S, McBirnie J, Gotterbarm T, et al. Midterm results of stemless impaction shoulder arthroplasty for primary osteoarthritis: a prospective, multicenter study. JSES Int. 2023;7(1):1–9.
57. Gee EC, Hanson EK, Saithna A. Reverse shoulder arthroplasty in rheumatoid arthritis: a systematic review. Open Orthop J. 2015;9:237–45.
58. Lévigne C, Chelli M, Johnston TR, Trojani MC, Molé D, Walch G, et al. Reverse shoulder arthroplasty in rheumatoid arthritis: survival and outcomes. J Shoulder Elbow Surg. 2021;30(10):2312–24.
59. Smolen JS, Aletaha D, McInnes IB. Rheumatoid arthritis. Lancet. 2016;388(10055):2023–38.
60. Polio W, Brolin TJ. Postoperative rehabilitation after shoulder arthroplasty. Phys Med Rehabil Clin N Am. 2023;34(2):469–79.
61. Fletcher D, Stamer UM, Pogatzki-Zahn E, Zaslansky R, Tanase NV, Perruchoud C, et al. Chronic postsurgical pain in Europe: an observational study. Eur J Anaesthesiol. 2015;32(10):725–34.

Publisher's Note