JSES Reviews, Reports, and Techniques 6 (2026) 100578

Available online at www.sciencedirect.com

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Risk factors for acromial and scapular fractures following reverse shoulder arthroplasty: a meta-analysis of over 100,000 shoulders

Khaled A. Elmenawi, MD[*], *John W. Sperling, MD, MBA, Joaquin Sanchez-Sotelo, MD, PhD, and Jonathan D. Barlow, MD*

Department of Orthopedic Surgery, Mayo Clinic, Rochester, MN, USA

A B S T R A C T

Background: Stress acromial fractures (AF) and scapular spine fractures (SSF) are rare but challenging complications of reverse total shoulder arthroplasty (rTSA). The purpose of our study was to identify risk factors of AF and SSF after rTSA through a detailed systematic review of published literature.

Methods: A systematic review of PubMed, Scopus, Web of Science, and Cochrane Library was conducted from inception to October 2023. We included all peer-reviewed studies investigating the risk of AF and SSF after rTSA, excluding biomechanical studies. A total of 1,047 publications were reviewed, and 25 publications with a total of 100,205 shoulders met our inclusion criteria. A meta-analysis of these publications was conducted using Comprehensive Meta-Analysis software. Odds ratios (OR) and 95% confidence intervals were used to estimate risks for categorical variables (gender, osteoporosis, inflammatory arthritis, and surgical history). Mean differences (MD) and standard deviations were used to determine the effect of continuous variables, such as age and body mass index (BMI).

Results: The pooled reported rate of AF and SSF was 2%. Our analyses identified a higher risk of AF and SSF in patients with osteoporosis (OR = 2.33, P = .004), inflammatory arthritis (OR = 2.19, P < .001), females (OR = 1.98, P < .001), and prior rotator cuff repair (OR = 2, P = .049). History of any shoulder surgery or prior acromioplasty were not associated with risk of fracture (P > .05). Patients with AF and SSF were older (MD = 1.82, P < .001) and presented a lower BMI (MD = −1.08, P < .001).

Conclusion: Patients who suffered AF or SSF after rTSA were older with lower BMI. Other risk factors identified included osteoporosis, inflammatory arthritis, female gender, and previous rotator cuff repair. There is, however, a need for further investigations into additional crucial factors, such as prosthesis type and design and lateralization of components, as these variables could significantly influence complication rates and patient outcomes following rTSA.

Level of evidence: Level IV; Systematic Review & Meta-Analysis

Keywords: Reverse shoulder arthroplasty; rTSA; Scapular fractures; Acromial fractures; AF; SSF

Institutional review board approval was not required for this systematic review and meta-analysis.

*Corresponding author: Khaled A. Elmenawi, MD, Department of Orthopedic Surgery, Mayo Clinic, 200 1st ST SW, Rochester, MN 55905, USA.

E-mail address: khaledelmenawi@gmail.com (K.A. Elmenawi).

https://doi.org/10.1016/j.xrrt.2025.08.015

Reverse total shoulder arthroplasty (rTSA) is on the rise globally and accounted for 69% of shoulder arthroplasties performed in the United States in 2020.[25] The success of rTSA in treating rotator cuff arthropathy patients has driven an expansion of its indications.[1] Advocates of increased use of rTSA justify the ample use of rTSA based on a lower risk of revision from subscapularis failure, as well as lower long-term risk of glenoid loosening and symptomatic rotator cuff failure.[3,5]

Despite its increased use, there are some unique complications of rTSA, particularly scapular notching, and fractures for screws of the acromion (acromial fractures [AF]) or scapular spine (scapular spine fractures [SSF]).[12] While AF and SSF are relatively rare, they are challenging to manage.[12] Recent reviews estimate their incidence to range between 2.6% and 8.4%.[7,18,21,31] While the exact mechanism remains unclear, several studies have suggested stress concentration at the deltoid origins secondary to changes in deltoid lever arm, baseplate screws acting as stress-risers, and repeated tuberosity abutment on the acromion as possible causes of AF and SSF following rTSA.[9,17,22,39] Overall, patients with AF and SSF after rTSA have demonstrated worse functional outcomes than those without fractures, highlighting the importance of understanding risk factors for developing these fractures.[31]

Previous studies have identified several risk factors for AF and SSF, such as older age, female sex, inflammatory arthritis, and osteoporosis. However, studies in the literature show inconsistent findings regarding other risk factors for AF and SSF.[8,23] With the increase in rTSA procedures performed and inconsistent findings in the literature, a systematic review and meta-analysis could elucidate the association of different risk factors with AF and SSF. The purpose of our study is to investigate the association of age, gender, body mass index (BMI), inflammatory arthritis, osteoporosis, and previous shoulder surgeries with risk of AF and SSF after rTSA. To our knowledge, this is the first meta-analysis in the peer-reviewed literature on the topic.

Materials and methods

Search strategy

A systematic review of PubMed, Scopus, Web of Science, and Cochrane Library was conducted from inception to October 21, 2023. This review was registered in the International Prospective Register of Systematic Reviews with the number "CRD42024495445" and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[29] The databases were searched using combinations of keywords detailed in Supplementary Appendix A. Titles and abstracts were screened by the authors. Full-text articles were then retrieved to determine eligibility. Details of screening steps are shown in Figure 1.

Eligibility

We included all studies, regardless of language, that reported numbers of AF or SSF based on the presence or absence of the following risk factors: female sex, inflammatory arthritis, osteoporosis, history of any ipsilateral shoulder surgery, history of ipsilateral rotator cuff repair, and history of ipsilateral acromioplasty. Studies that compared age and BMI in patients with and without AF or SSF were also included. We excluded studies that are irrelevant to our topic, duplicate studies, reviews, and biomechanical studies. When studies with overlapping cohorts were found eligible for the same analysis, we included only the study with the larger cohort. Table I summarizes the studies included for this review.

Quality assessment

The Newcastle-Ottawa Scale for observational studies was used for quality assessment. The Newcastle-Ottawa Scale is 9-point scoring questionnaire assessing the selection, comparability, and outcomes for each study. According to the score, studies were categorized into good-quality studies (7-9 points), moderate-quality studies (5-6 points), and low-quality studies (0-4 points). Details of the quality assessment for each study demonstrated in Supplementary Appendix B.

Data extraction

From each study, the data collected included means and standard deviations (SDs), sample sizes, numbers of fractures, year of publication, location of fracture (AF/SSF), method of fracture diagnosis, and follow-up time. Data extraction was repeated twice, and raw numbers were used for analyses.

Analysis

We used Comprehensive Meta-Analysis software (version 3.3.070) to compare means (SD) for continuous variables and calculate odds ratio (OR) and 95% confidence interval (CI) for categorical variables utilizing a random-effects model to account for variability among the studies included.[6] Numbers of fractures and sample sizes were used for OR calculations and means (SD) were used for mean difference (MD) calculations. A P value $< .05$ was considered statistically significant. Heterogeneity was assessed using I^2 test; with $I^2 > 50\%$ considered as high heterogeneity. Sensitivity analysis was performed to test the effect of some studies on overall results.

Results

We retrieved 1,047 articles from the databases search. After removing the duplicates, 347 articles remained for title and abstract screening. Of these 347 abstracts, 41 were found to be potentially eligible, and their full texts were retrieved. Ultimately, 25 articles were included in our analysis. Details of screening process and reasons for exclusion are shown in Figure 1. Overall, 100,205 rTSA were included in our analysis with 1,937 (2%) cases of AF and SSF.

Age

When analyzing the 7 studies that compared means (SD) between patients with and without AF and SSF, patients with

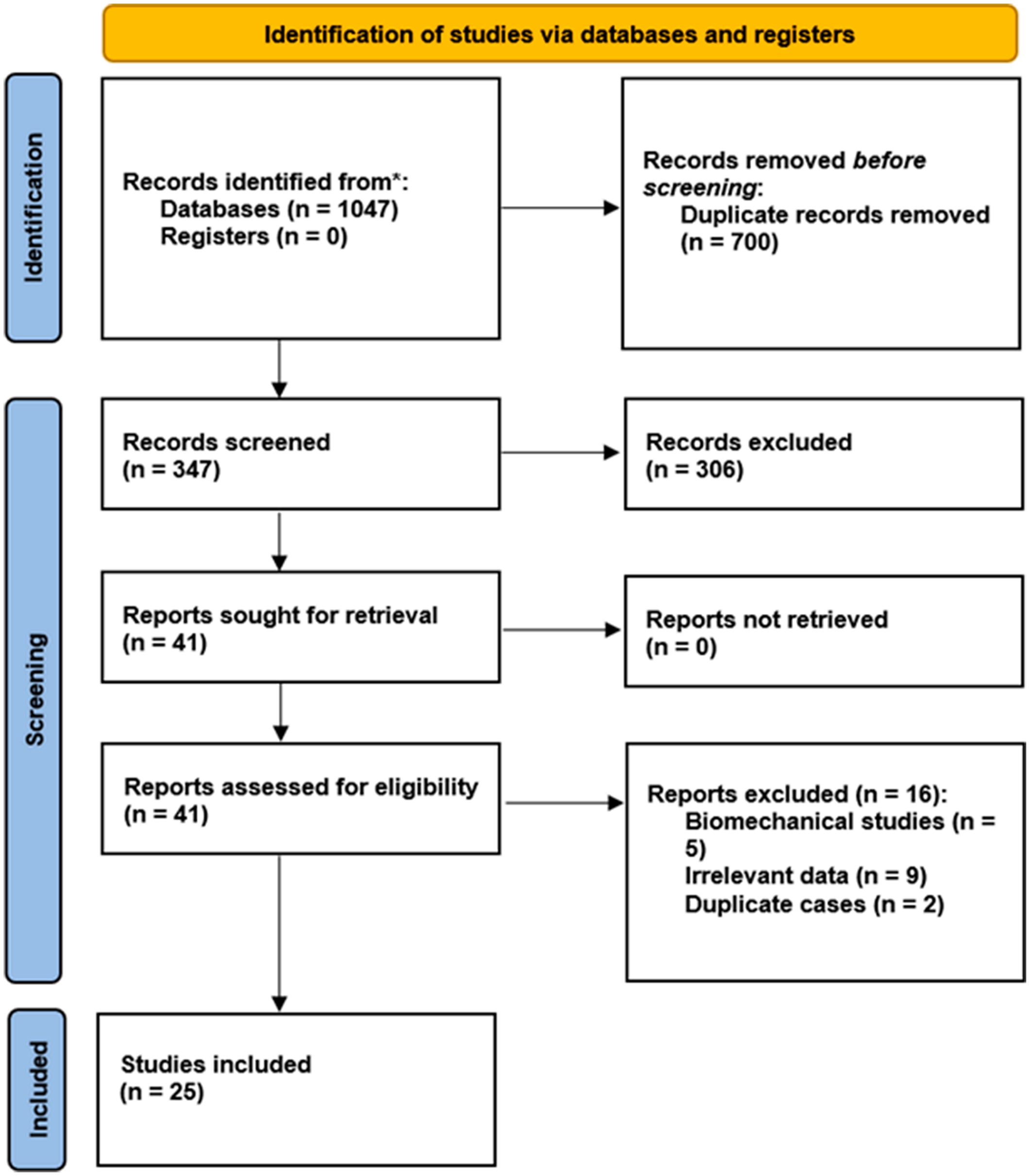

Figure 1 – PRSIMA flow chart. *PRISMA*, preferred reporting items for systematic reviews and meta-analyses.

AF and SSF were older than controls (MD = 1.82, 95% CI 1.13-2.51, $P < .001$). A forest plot for age comparison is shown in Figure 2. No heterogeneity was found in this analysis ($I^2 = 0\%$).

Body Mass Index

There were 6 studies comparing means (SD) for BMI between patients with and without AF and SSF. Our analysis demonstrated a lower BMI in patients with AF and SSF than controls (MD = −1.08, 95% CI −1.62, −0.54, $P < .001$). A forest plot for BMI comparison is shown in Figure 3. No heterogeneity was found in this analysis ($I^2 = 0\%$).

Gender

We found 12 studies with data on stress fracture risk based on gender. When analyzing fracture risk for female sex, we found females to be twice more likely to develop AF and SSF than males (OR = 1.98, 95% CI 1.65-2.38, $P < .001$). A forest plot for risk based on gender is shown in Figure 4. No heterogeneity was found in this analysis ($I^2 = 0\%$).

Osteoporosis

A total of 7 studies compared risk of AF and SSF with and without osteoporosis. We identified more than twice the

Table I – Summary of studies included in analysis.

Study	Year	Number of rTSA included in meta-analysis (n = 100,205)	Number of fractures (n = 1937)	Type of fracture	Criteria for AF or SSF diagnosis	Duration of follow-up
Blaber et al[4]	2023	90	3	AF/SSF	Clinical and radiological assessment	Mean 52.6 mo (IQR, 49.1 mo) for cases Mean 68 mo (IQR, 41.8 mo) for controls
Cho et al[8]	2021	787	29	AF	Clinical and radiological assessment	Mean 31.6 mo (range, 12-136 mo)
Dean et al[10]	2022	192	2	Stress fractures not otherwise specified	Clinical and radiological assessment	Mean 36.3 mo with minimum 2 yr of follow-up (range not reported)
Dubrow et al[11]	2014	125	14	AF	Clinical and radiological assessment	Mean 19.7 mo (range, 1-68 mo)
Gutman et al[13]	2021	958	43	AF	Clinical and radiological assessment	Mean 50.3 mo (range, 24-108 mo)
Haidamous et al[14]	2020	426	26	SSF	Clinical and radiological assessment	Mean 12.9 mo (range, 3-32 mo)
Hamid et al[15]	2011	162	8	AF	Clinical and radiological assessment	Mean 14 mo (range, 9-66 mo)
Hattrup et al[16]	2010	125	9	AF/SSF	Clinical and radiological assessment	Mean 30 mo (range, 12-48 mo)
Kriechling et al[19]	2023	860	45	AF/SSF	Clinical and radiological assessment	Minimum 2 yr
Mahendraraj et al[23]	2021	6,755	264	AF/SSF	Clinical and radiological assessment	Mean 19.8 mo (range, 3-94 mo)
Marigi et al[23]	2020	2,172	36	AF/SSF	Clinical and radiological assessment	Mean 4.3 yr (SD, 0.6 yr)
Miller et al[25]	2021	335	22	AF/SSF	Clinical and radiological assessment	Mean 2 yr (range, 3-80 mo)
Moverman et al[26]	2021	1,479	54	AF	Clinical and radiological assessment	Mean 36 mo (range not reported)
Otto et al[28]	2013	264	52	SSF	Clinical and radiological assessment	Mean 15.2 mo (range, 1-95 mo)
Patel et al[29]	2020	150	3	AF	Clinical and radiological assessment	Mean 3.8 yr (range, 2-10 yr) for cases Mean 3.3 yr (range, 2-8 yr) for controls
Roche et al[31]	2023	9,079	138	AF/SSF	Clinical and radiological assessment	Mean 26.5 mo (SD, 23.9 mo) for cases Mean 26.2 mo (SD, 26.4 mo) for controls
Routman et al[32]	2020	4,125	61	AF/SSF	Clinical and radiological assessment	Mean 27.8 mo (SD, 20.6 mo)
Schenk et al[33]	2020	95	21	AF	Clinical and radiological assessment	Mean for cases 50 mo (range, 4-184 mo) Mean for control 50 mo (range, 4-189 mo)
Shields et al[34]	2017	272	3	AF/SSF	Not specified	Mean 25 mo (SD, 13 mo) for cases Mean 26 mo (SD, 13 mo) for controls
Su et al[35]	2023	67,510	972	AF	ICD-9 and ICD-10 codes	Minimum 2 yr
Townsend et al[37]	2022	55	11	AF/SSF	Clinical and radiological assessment	Mean 4 y (range, 0.5-9.7 yr)
Verstraete et al[38]	2021	2038	63	AF/SSF	Clinical and radiological assessment	Minimum 1 yr
Werthel et al[40]	2018	1,094	12	AF	Clinical and radiological assessment	Mean 2.2 yr (range, 0-7 yr)
Yeazell et al[41]	2020	99	6	AF	Clinical and radiological assessment	Mean 15.5 mo (range, 7-37 mo)
Zmistowski et al[42]	2020	958	40	AF	Clinical and radiological assessment	Mean 407 d (range, 90-1,698 d)

rTSA, reverse total shoulder arthroplasty; *AF*, acromial stress fractures; *SSF*, scapular spine fractures; *IQR*, interquartile range; *SD*, standard deviation; *ICD*, International Classification of Diseases.

Age Comparison

Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study						
Kriechling 2023	3.000	1.394	1.945	0.267	5.733	2.151	0.031
Mahendraraj 2021	1.800	0.544	0.296	0.734	2.866	3.309	0.001
Moverman 2021	3.100	1.123	1.261	0.899	5.301	2.761	0.006
Zmistowski 2020	0.700	1.523	2.319	-2.285	3.685	0.460	0.646
Marigi 2020	-0.200	1.650	2.722	-3.434	3.034	-0.121	0.904
Roche 2023	1.700	0.703	0.494	0.323	3.077	2.419	0.016
Cho 2021	1.700	1.401	1.962	-1.046	4.446	1.214	0.225
	1.823	0.353	0.125	1.131	2.515	5.163	0.000

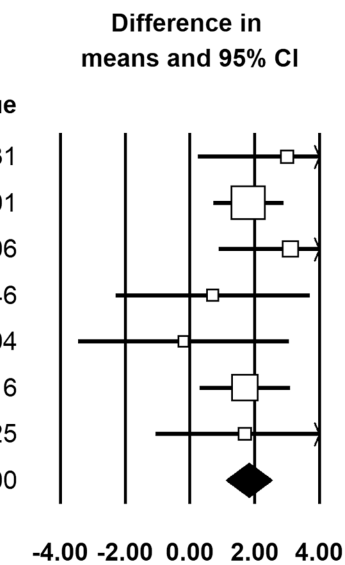

Figure 2 – Forest plot for age comparison. *CI*, confidence interval.

risk of AF and SSF in osteoporotic patients (OR = 2.33, 95% CI 1.30-4.16, *P* = .004). A forest plot for risk of fracture with osteoporosis is shown in Figure 5. High heterogeneity was found in this analysis (I^2 = 71.5%).

Inflammatory arthritis

Our analysis of 5 studies showed that patients with inflammatory arthritis as a comorbidity were approximately twice more likely to develop AF and SSF than controls (OR = 2.19 (95% CI 1.88-2.56, *P* < .001). A forest plot for risk of fracture with inflammatory arthritis is shown in Figure 6. No heterogeneity was found in this analysis (I^2 = 0%).

Surgical history

We analyzed the risk of AF and SSF in shoulders with previous surgery. There were 8 studies investigating risk of fractures with any previous ipsilateral shoulder surgery, 5 studies investigating risk of fractures with prior rotator cuff repair, and 3 studies investigating risk associated with previous acromioplasty.

There was no statistically significant risk of AF and SSF in patients with history of any ipsilateral shoulder surgery compared to patients with no previous ipsilateral shoulder surgery (OR = 1.06, 95% CI 0.77-1.46, *P* = .771), as shown in Figure 7. Slightly high heterogeneity was found in this analysis (I^2 = 51%). When analyzing risk of AF and SSF in patients with and without prior rotator cuff repair, a higher risk of AF and SSF was associated with prior rotator cuff repair (OR = 2, 95% CI 1.0-4.25, *P* = .049), as shown in Figure 8. Low heterogeneity was found in this analysis (I^2 = 37.4%). We found a statistically insignificant association between prior acromioplasty and risk of AF and SSF (OR = 2.94, 95% CI 0.30-28.6, *P* = .352), as demonstrated in Figure 9. High heterogeneity was found in this analysis (I^2 = 87%).

Sensitivity analysis

We removed 4 large database studies (Mahendraraj et al,[23] Roche et al,[32] Routman et a.,[33] Su et al[36]) that potentially included duplicate patients with the studies analyzed to determine change in effect and significance. We observed no statistically significant changes after removal of these studies separately and simultaneously, indicating they had no additional effect on overall results.

Discussion

AF and SSF are estimated to occur in 2.6%-8.4% of patients after rTSA.[7,18,21,31] While many studies, including review articles, have investigated risk factors of AF and SSF, inconsistency remain in the literature. Our review included 25 studies with a total of 100,205 rTSAs and 1,937 (2%) stress fractures. We found older age (MD = 1.82, *P* < .001) and lower BMI (MD = −1.08, *P* < .001) in patients with SF and AF compared to controls. In addition, there were statistically significant higher risks of AF and SSF with osteoporosis (OR = 2.33, *P* = .004), inflammatory arthritis (OR = 2.19, *P* < .001), female sex (OR = 1.98, *P* < .001), and prior rotator cuff repair (OR = 2, *P* = .049). Prior shoulder surgery of any sort (*P* = .771) and prior acromioplasty (*P* = .352) were not associated with a higher risk of fracture.

In our analysis, we found osteoporosis and inflammatory arthritis to be the strongest risk factors for AF and SSF. Both conditions are associated with decreased bone density, leaving patients predisposed to AF and SSF.[2,27] In addition,

BMI Comparison

Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Cho 2021	-0.600	0.715	0.512	-2.002	0.802	-0.839	0.402
Kriechling 2023	-1.000	0.782	0.612	-2.533	0.533	-1.278	0.201
Gutman 2021	-2.000	0.948	0.899	-3.858	-0.142	-2.110	0.035
Marigi 2020	-0.900	1.144	1.309	-3.142	1.342	-0.787	0.431
Roche 2023	-0.600	0.515	0.266	-1.610	0.410	-1.164	0.244
Mahendraraj 2021	-1.600	0.505	0.255	-2.589	-0.611	-3.171	0.002
	-1.084	0.276	0.076	-1.624	-0.544	-3.932	0.000

Difference in means and 95% CI

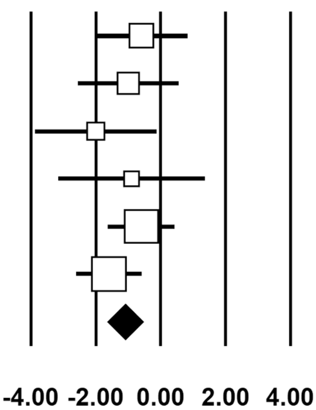

Figure 3 – Forest plot for body mass index comparison. *CI*, confidence interval; *BMI*, body mass index.

Gender

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Cho 2021	1.081	0.455	2.570	0.176	0.860
Dubrow 2014	2.538	0.538	11.975	1.177	0.239
Haidamous 2020	1.410	0.614	3.241	0.810	0.418
Kriechling 2023	1.892	0.940	3.808	1.788	0.074
Mahendraraj 2021	2.024	1.525	2.686	4.884	0.000
Zmistowski 2020	1.626	0.785	3.369	1.308	0.191
Yeazell 2020	0.862	0.149	4.979	-0.167	0.868
Hamid 2011	8.538	0.484	150.644	1.464	0.143
Hattrup 2010	6.889	0.816	58.178	1.773	0.076
Marigi 2020	1.401	0.697	2.817	0.947	0.344
Roche 2023	2.482	1.644	3.746	4.328	0.000
Versatraete 2020	3.214	1.377	7.499	2.701	0.007
	1.986	1.653	2.387	7.322	0.000

Odds ratio and 95% CI

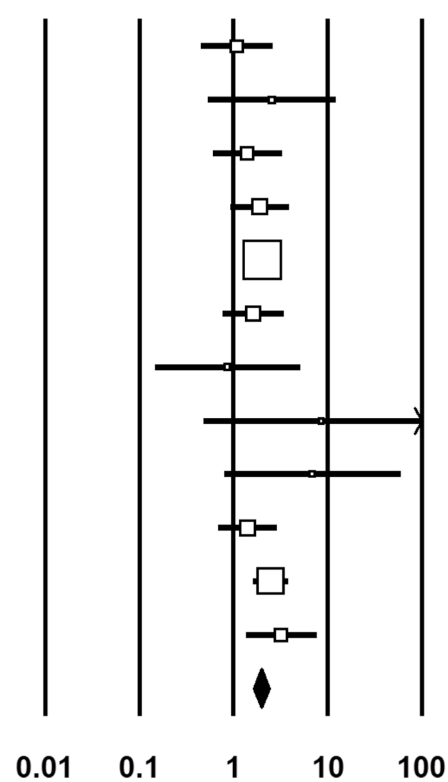

Figure 4 – Forest plot for risk of stress fracture based on gender. *CI*, confidence interval.

Osteoporosis

Study name	MH odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Haidamous 2020	0.303	0.018	5.129	-0.827	0.408
Mahendraraj 2021	1.210	0.911	1.607	1.313	0.189
Yeazell 2022	3.429	0.644	18.259	1.444	0.149
Gutman 2021	5.257	2.622	10.538	4.676	0.000
Otto 2013	1.972	0.995	3.906	1.946	0.052
Schenk 2022	3.318	1.097	10.036	2.124	0.034
Versatraete 2021	2.822	1.263	6.308	2.529	0.011
	2.332	1.307	4.160	2.868	0.004

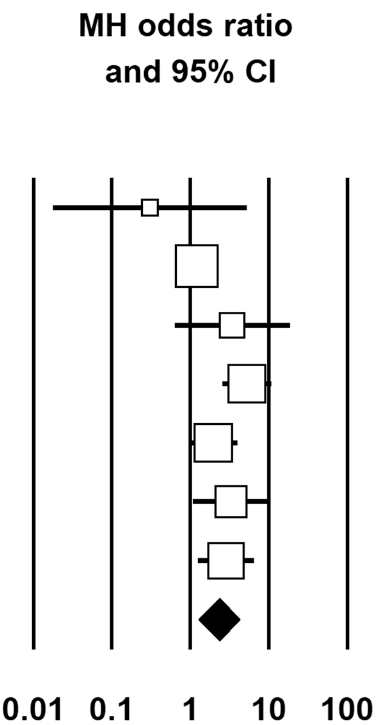

Figure 5 – Forest plot for risk of stress fracture based on osteoporosis. *CI*, confidence interval.

Inflammatory Arthritis

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Mahendraraj 2021	2.504	1.846	3.396	5.903	0.000
Routman 2020	2.991	1.267	7.062	2.500	0.012
Miller 2021	4.171	1.483	11.728	2.707	0.007
Moverman 2021	2.520	1.155	5.497	2.322	0.020
Su 2023	1.992	1.646	2.411	7.079	0.000
	2.195	1.882	2.561	10.006	0.000

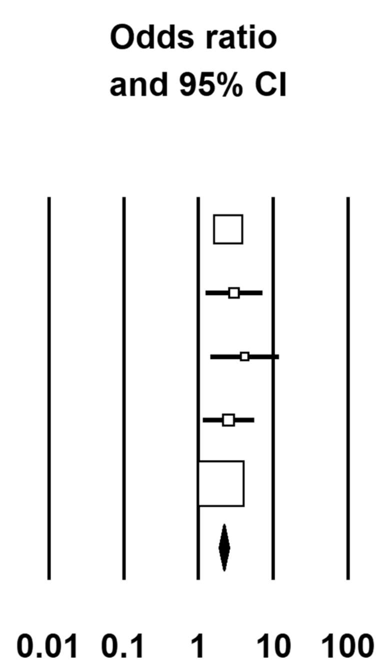

Figure 6 – Forest plot for risk of stress fracture based on inflammatory arthritis. *CI*, confidence interval.

History of Any Shoulder Surgery

MH odds ratio	Study name	Lower limit	Upper limit	Z-Value	p-Value
2.358	Cho 2021	1.091	5.096	2.182	0.029
0.375	Kriechling 2023	0.172	0.816	-2.472	0.013
1.248	Mahendraraj 2021	0.965	1.614	1.690	0.091
1.325	Roche 2022	0.937	1.873	1.594	0.111
1.000	Schenk 2022	0.347	2.882	0.000	1.000
0.542	Townsend 2022	0.126	2.325	-0.825	0.409
0.700	Werthel 2018	0.185	2.648	-0.525	0.599
0.979	Otto 2013	0.514	1.864	-0.066	0.948
1.063		0.770	1.467	0.370	0.711

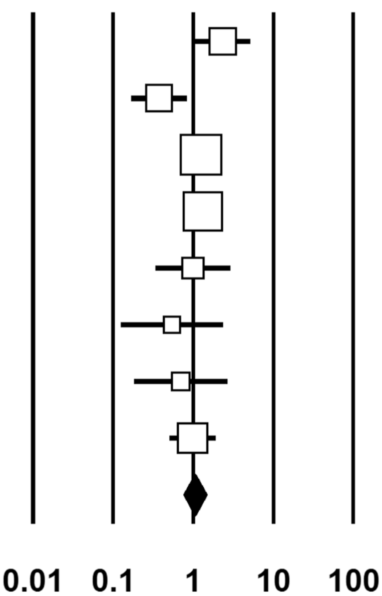

Figure 7 – Forest plot for risk of stress fracture based on history of shoulder surgery. CI, confidence interval.

patients with inflammatory arthritis are often treated with corticosteroids, which may further decrease mineral bone density.[2] Miller et al reported a 24% incidence of AF and SSF in rheumatoid arthritis patients compared to only 5% in their control group.[26] As such, previous authors have suggested preventative measures in patients with rheumatoid arthritis who are undergoing rTSA, such as limiting arm lengthening during surgery and avoiding strengthening exercises to decrease postoperative tension.[26] In patients undergoing rTSA, the risk of AF and SSF differs by gender.[23] Mahendraraj et al showed that the risk increases by 1.5 and 2.3 times in females relative to males for AF and SSF, respectively.[23] However, Cho et al did not find the same association.[8] Our pooled analysis of 12 studies showed an overall higher risk of stress fractures in females compared to males (OR = 1.98, $P < .001$).

The impact of previous shoulder surgeries on the development of AF and SSF remains controversial. Cho et al compared risk of AF and SSF in patients with and without any shoulder surgery.[8] They demonstrated a higher risk of fracture in patients with previous shoulder surgeries (OR = 2.91, $P = .034$).[8] In contrast, Kriechling et al found prior shoulder surgery to be associated with a lower risk of AF and SSF.[19] We analyzed 8 studies comparing the risk of AF and SSF after rTSA in patients with previous shoulder surgeries of any sort compared to patients without and found no statistically significant difference in risk ($P = .711$). Similarly, we found no statistically significant difference in AF and SSF risk when comparing shoulders with and history of acromioplasty ($P = .352$). In patients undergoing rTSA, a history of rotator cuff repair has been associated with worse outcomes.[10] Dean et al demonstrated worse outcomes and more complications after rTSA in patients with prior rotator cuff repair.[10] We retrieved 5 studies reporting numbers of AF and SSF after rTSA.[10,24,30,33,35] Interestingly, these 5 studies showed a higher rate of AF and SSF in the cohort with prior rotator cuff repair but did not find a statistically significant association. Our pooled analysis revealed a higher risk of stress fracture after rTSA in patients with prior rotator cuff repair (OR = 2, $P = .49$). Although a P value of .049 is borderline for statistical significance, our comprehensive analysis of the literature (5 studies) provides strong evidence suggestive of an association between previous rotator cuff repair and AF/SSF. It is crucial to note that implant lateralization, model, and design (onlay vs. inlay) were not accounted for in our analyses due to inconsistent reported and heterogeneity. Distalization and lateralization, which are common with the onlay design, may increase the tension across the deltoid, potentially increasing the likelihood of SSF.[14] However, this association was found to be statistically insignificant in a recent meta-analysis despite the higher rate of SSF with onlay in comparison to inlay designs.[20]

The main limitation in our study is the heterogeneity found in some of our analyses. However, this is to be expected due to differences in follow-up durations, surgical procedures, and

Prior Rotator Cuff Repair

Study name	MH odds ratio	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study				
Marigi 2020	3.116	1.593	6.094	3.320	0.001
Patel 2020	2.027	0.180	22.848	0.572	0.567
Routman 2020	1.102	0.663	1.830	0.375	0.708
Shields 2017	4.642	0.415	51.919	1.246	0.213
Dean 2022	6.302	0.299	133.032	1.183	0.237
	2.067	1.004	4.253	1.971	0.049

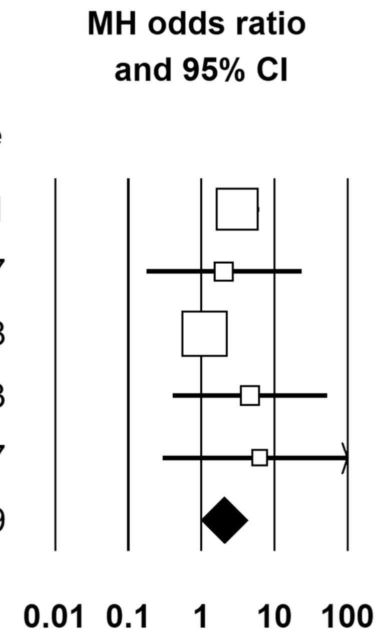

Figure 8 – Forest plot for risk based on history of prior rotator cuff repair. *CI*, confidence interval.

Prior Acromioplasty

Study name	MH odds ratio	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study				
Blaber 2023	0.489	0.043	5.589	-0.576	0.565
Schenk 2022	1.833	0.432	7.789	0.821	0.412
Marigi 2020	16.203	7.890	33.272	7.587	0.000
	2.944	0.303	28.605	0.931	0.352

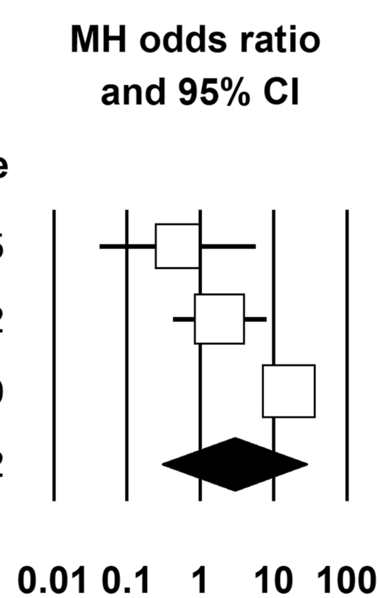

Figure 9 – Forest plot for risk of stress fracture based on history of acromioplasty. *CI*, confidence interval.

patient characteristics. We used a random-effects model to account for these variations in our analysis. Nonetheless, these findings should be interpreted with caution, particularly regarding osteoporosis and prior acromioplasty, due to the moderate-to-high heterogeneity observed in our analysis. Another potential limitation is the inclusion of 4 studies[23,32,33,36] that used large databases and may have duplicate patients with the other studies in the analysis. Large database studies, like those in our analysis, often include patients who may also appear in single-institution databases. However, significant differences in how data are recorded and retrieved across these sources make it challenging to accurately estimate any overlap. However, we do not believe this affected our results, as evidenced by our sensitivity analysis showing no changes in statistical significance nor effect direction when those 4 studies were removed from their respective analyses.

Conclusion

In our study of 25 publications with over 100,000 rTSA analyzed, patients with AF and SSF following rTSA were older (MD = 1.82, $P < .001$) and had a lower BMI (MD = −1.08, $P < .001$). The risk of AF and SSF was higher in those with osteoporosis (OR = 2.33, $P = .004$), inflammatory arthritis (OR = 2.19, $P < .001$), female sex (OR = 1.98, $P < .001$), and prior rotator cuff repair (OR = 2, $P < .049$). We found no association between having prior shoulder surgery of any sort or prior acromioplasty and the risk of AF or SSF after rTSA. Additional studies are needed to investigate the effect of implant configuration on AF and SSF when considered in the light of these demographic and patient-related factors.

Disclaimers:

Funding: No funding was disclosed by the authors.

Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article. Given his role as Editor in Chief, Dr John W. Sperling had no involvement in the peer-review of this article and has no access to information regarding its peer-review. Full responsibility for the editorial process for this article was delegated to Dr Peter N. Chalmers.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.xrrt.2025.08.015.

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