Title

End-stage renal disease patients have comparable results to renal transplant patients after shoulder arthroplasty.

Journal

JSES International, 7(6)

Authors

Chiou, Daniel
Chen, Kevin
Ahlquist, Seth
et al.

Publication Date

2023-11-01

DOI

10.1016/j.jseint.2023.04.008

Peer reviewed

JSES International 7 (2023) 2420–2424

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

End-stage renal disease patients have comparable results to renal transplant patients after shoulder arthroplasty

Daniel Chiou, MD[a,*], Kevin Chen, BA[a], Seth Ahlquist, MD[a], Peter Hsiue, MD[a], Alexandra Stavrakis, MD[a], Christos Demetris Photopoulos, MD[b]

[a]Department of Orthopaedic Surgery, University of California Los Angeles, Los Angeles, CA, USA
[b]Kerlan-Jobe Orthopaedic Institute, Los Angeles, CA, USA

ARTICLE INFO

Keywords:
Shoulder arthroplasty
End-stage renal disease
Renal transplant
Infection
Reimplantation
Postoperative complications

Level of Evidence: Level III; Retrospective Cohort Comparison using Large Database; Prognosis Study

Background: End-stage renal disease (ESRD) and renal transplant (RT) patients are known to have more perioperative and postoperative complications after arthroplasty surgeries when compared to patients without. We hypothesize that RT patients undergoing shoulder arthroplasty (SA) have fewer systemic and surgical complications when compared to ESRD patients undergoing SA.

Methods: This was a retrospective review from the PearlDiver Patient Record Database. International Classification of Diseases and Current Procedural Terminology codes were used to identify patients who had undergone primary total and reverse shoulder arthroplasty, respectively, and subsequent surgical revisions. Unadjusted univariate analysis of patient demographics, Charlson Cormorbidty Index, and surgical complications at 90 days, 1 year, and 2 years after was performed using chi-squared testing. Multivariate logistic regression analyses were subsequently performed for systemic complications and prosthesis outcomes at all time points.

Results: Of 1191 patients with ESRD or previous RT and who underwent either total shoulder arthroplasty or reverse total shoulder arthroplasty, 1042 (87.5%) had ESRD and 149 (12.5%) had a previous RT. ESRD SA patients were more likely to have hypertension, liver disease, coronary artery disease, and hypothyroidism. Interestingly no statistical significance was found in multivariate analysis for systemic complications at 90 days, nor for surgical complications at the 90-day, 1-year, or 2-year mark between ESRD and RT cohorts.

Conclusion: SAs have comparable outcomes in ESRD and RT patients. The differing conclusions among studies might be partially accounted for by the demographic differences and comorbidities between these 2 patient populations. Providers should continue to provide appropriate counseling concerning risks, benefits, and timing of SA for these patients.

Because of the aging population, it is estimated that up to one-third of people older than 60 years suffer from glenohumeral arthritis.[35] Depending on glenoid bone stock and rotator cuff functionality, there are different options for shoulder arthroplasty (SA) for patients who have failed conservative management. Anatomic total shoulder arthroplasty is indicated for patients with an intact rotator cuff and sufficient glenoid bone, while those who have physically demanding lives or poor glenoid bone stock can benefit from a hemiarthroplasty.[11-14,16,18,29] Reverse SA are indicated in patients with rotator cuff deficiency.[20] SA is also reliable options for improving function, relieving pain, and treating fractures and cuff arthropathies in patients when conservative management has failed.[8,19,21,28,33,46] Although SA procedure volume has exponentially increased over the last 2 decades, postoperative complications still occur in almost 10% of patients.[5]

Renal transplant (RT) and end-stage renal disease (ESRD) patients have a documented increased risk of complications following arthroplasty surgeries.[6,9,10,22,24,25,28,30,32,34,37,40,43-45,47,49] ESRD patients have a 10 times increased risk of death, 4-fold increased risk of infections following total hip arthroplasty (THA) and total knee arthroplasty (TKA) surgeries.[10,36] RT gives patients with ESRD improvement in renal function leading to lower mortality rates and better quality of life when compared to patients with ESRD.[4,12] However, because both RT and renal disease patients have concomitant chronic conditions and are chronically

Institutional reviewboard approval was not required for the deidentified database study.

*Corresponding author: Daniel Chiou, MD, Department of Orthopaedic Surgery, Sports Medicine, University of California at Los Angeles Health System, 100 Medical Plaza Driveway, Suite 170, Los Angeles, CA 90095, USA.
E-mail address: danielchiou@mednet.ucla.edu (D. Chiou).

https://doi.org/10.1016/j.jseint.2023.04.008

Table I
Baseline patient characteristics.

	ESRD n = 1042 (82.5%)	RT n = 149 (17.5%)	*P* value
Age			
<40	4 (0.38)	3 (2.01)	.063
40-49	11 (1.06)	3 (2.01)	**.013**
50-59	94 (9.02)	26 (17.45)	**.002**
60-69	282 (27.06)	63 (42.28)	**<.001**
70-79	547 (52.5)	52 (34.9)	**<.001**
≥80	87 (8.35)	1 (0.67)	**.001**
Gender			
Male	436 (41.84)	79 (53.02)	**.01**
Female	606 (58.16)	70 (46.98)	**.01**
Charlson Comorbidity Index			
0	18 (1.73)	3 (2.01)	.12
1	16 (1.54)	4 (2.68)	.496
2	61 (5.85)	18 (12.08)	**.007**
3	129 (12.38)	16 (10.74)	.66
4	140 (13.44)	19 (12.75)	.92
≥5	678 (65.07)	86 (57.72)	.097

ESRD, end-stage renal disease; *RT*, renal transplant.
The significance of the bold is that it indicates statistical significance based on *P* value <.05.

Table II
Baseline patient comorbidities.

	ESRD	RT	*P* value
	N (%)	N (%)	
DM	545 (52.3)	66 (44.3)	.082
HTN	902 (86.56)	117 (78.52)	**.013**
Liver disease	77 (7.39)	21 (14.09)	**.009**
Obesity	291 (27.93)	31 (20.81)	.083
Weight loss	69 (6.62)	12 (8.05)	.635
Hypothyroidism	273 (26.2)	21 (14.09)	**.002**
CVD	154 (14.78)	13 (8.72)	.062
MI	98 (9.40)	11 (7.28)	.516
CAD	342 (32.82)	35 (23.49)	**.028**
CHF	67 (6.43)	16 (10.74)	.078
PVD	215 (20.63)	23 (15.44)	.169
Pulmonary heart disease	100 (9.6)	13 (8.72)	.849
Ischemic heart disease	75 (7.2)	5 (3.36)	.115
Valvular disease	194 (18.62)	13 (8.72)	**.004**
Arrhythmias	319 (30.61)	40 (26.85)	.4
Coagulopathy	89 (8.54)	16 (10.74)	.465
Deficiency anemia	213 (20.44)	22 (14.77)	.129
Asthma	127 (12.19)	13 (8.72)	.275
Solid tumor	105 (10.08)	16 (10.74)	.916
Cancer	115 (11.04)	19 (12.75)	.63
Metastatic cancer	25 (2.4)	2 (1.34)	.606
RA	35 (3.36)	10 (6.71)	.075
Tobacco use	60 (5.76)	11 (7.38)	.55
Alcohol use	33 (3.17)	4 (2.68)	.948
Drug abuse	63 (6.05)	8 (5.37)	.888
Depression	266 (25.53)	29 (19.46)	.132
Dementia	40 (3.84)	3 (2.01)	.378

HTN, hypertension; *CHF*, congestive heart failure; *CAD*, coronary artery disease; *PVD*, peripheral vascular disease; *CVD*, cardiovascular disease; *DM*, diabetes mellitus; *RA*, rheumatoid arthritis; *MI*, myocardial infarction; *ESRD*, end-stage renal disease; *RT*, renal transplant.
The significance of the bold is that it indicates statistical significance based on *P* value <.05.

immunosuppressed, they are prone to postoperative complications following arthroplasty surgeries. Such complications include deep venous thrombosis (DVT), periprosthetic joint infections (PJIs), aseptic loosening (AL), wound complications, and periprosthetic fractures (PPFs).[2,6,9,22,28,30,35,49] The majority of such studies focus on patients undergoing TKA and THA surgery, respectively, few however have investigated SA. In addition, there have been no studies comparing SA postoperative risks between ESRD and RT patients. As long-term survival for RT and ESRD patients continues to increase, more of these patients will require arthroplasty surgeries in the future.[39,40] It is vital to have an understanding of postoperative complication profiles for these 2 patients groups so that they can be informed of the risks and benefits of proceeding with SA. Furthermore, the findings in this study may allow for guidance on whether or not patients with ESRD who are RT candidates requiring SA should proceed with SA before or after transplant. The purpose of this study was to determine and compare the demographics and postoperative medical and surgical complications between RT and ESRD patients receiving SA. We hypothesize that ESRD patients will have more postoperative complications when compared to RT patients.

Methods

This retrospective study used the PearlDiver Patient Record Database (PearlDiver [www.pearldiver.inc], Fort Wayne, IN, USA), a commercially available repository of 41 billion Health Insurance Portability and Accountability Act of 1996-compliant patient records. Specifically, the "MUExtr" dataset within PearlDiver was used, which is comprised of medical records for privately insured, Medicare, and Medicaid patients across the United States who have undergone upper extremity procedures. International Classification of Diseases, 10th revision diagnosis (ICD-10) and Current Procedural Terminology procedure codes were used to identify all adult patients who underwent primary total shoulder arthroplasty (TSA) and reverse TSA for arthritis or cuff arthropathy from 2015-2019. ICD-10 and Current Procedural Terminology codes were used to include both primary TSA and reverse TSA cases into patients who had concurrent ESRD and patients who had undergone previous RT. Patients with a history of fracture, revisions, or infections were excluded. All collected data were deidentified and exempt from institutional review board requirements.

The primary study outcomes evaluated included medical complications at 90 days and surgical complications at 90 days, 1 year, and 2 years post-SA. Systemic complications included cardiac arrest, DVT, pneumonia, pulmonary embolism, urinary tract infection (UTI), sepsis, reintubation, wound disruption, hematoma, and need for transfusion. Surgical complications included PPF, PJI, stiffness, instability, and AL.

All data analysis was performed using the R statistical software package (Vienna, Austria) integrated within PearlDiver. Patient demographics, comorbidities (defined as diagnoses occurring within 1 year of index SA), and hospital factor data were compared between patient groups using Welch's 2-sample *t*-test for continuous variables and the chi-square test for categorical variables. Categorical variables are displayed as frequency and percentage of the cohort, while continuous variables are shown as means with standard error. Multivariable logistic regression was performed for systemic complications and prosthesis outcomes of interest while controlling for age, gender, Charlson Comorbidity Index (CCI), diabetes mellitus, and all other comorbidities found to be significantly different in the univariate analysis (Tables I and II). Significance was determined with a 2-tailed *P* value of .05.

Results

A total of 1191 patients with ESRD or RT undergoing SA were identified during the study period. There were 1042 (87.5%) patients with ESRD and 149 (12.5%) patients with a previous RT.

Table III
Systemic complications at 90 days.

	ESRD	RT	OR (95% CI)	*P* value
	N (%)	N (%)		
Cardiac arrest	2 (0.19)	0 (0)	NA	NA
DVT	15 (1.44)	3 (2.013)	1.33 (0.36-4.85)	.671
Pneumonia	43 (4.13)	3 (2.013)	1.72 (0.78-3.76)	.176
Transfusion	20 (1.92)	1 (0.67)	0.34 (0.02-1.7)	.297
PE	1 (0.096)	(0)	NA	NA
UTI	83 (7.97)	2 (1.34)	0.95 (0.43-1.9)	.9
Sepsis	27 (2.59)	3 (2.013)	0.85 (0.2-2.52)	.792
Reintubation	5 (0.48)	0 (0)	NA	NA
Disruption of wound	8 (0.77)	1 (0.67)	0.65 (0.03-3.71)	.686
Hematoma	2 (0.19)	0 (0)	NA	NA

DVT, deep vein thrombosis; *PE*, pulmonary embolism; *UTI*, urinary tract infection; *ESRD*, end-stage renal disease; *RT*, renal transplant; *OR*, odds ratio; *CI*, confidence interval.

Table IV
Surgical complications at 90 days.

	ESRD	RT	OR (95% CI)	*P* value
	N (%)	N (%)		
PPFX	29 (2.78)	1 (0.67)	0.3 (0.02-1.48)	.244
PJI	3 (0.29)	1 (0.67)	7.31 (0.19-2.38)	.228
Stiffness	98 (9.4)	14 (9.4)	1.01 (0.53-1.81)	.97
Instability	37 (3.55)	3 (2.01)	0.53 (0.13-1.53)	.304
Aseptic loosening	0	0	N/A	N/A

PPFX, periprosthetic fracture; *PJI*, prosthetic joint infection; *ESRD*, end-stage renal disease; *RT*, renal transplant; *OR*, odds ratio; *CI*, confidence interval.

Table V
Surgical complications at 1 year.

	ESRD	RT	OR (95% CI)	*P* value
	N (%)	N (%)		
PPFX	40 (3.84)	3 (2.01)	0.5 (0.12-1.42)	.255
PJI	5 (0.48)	1 (0.67)	1.73 (0.08-16.6)	.661
Stiffness	123 (11.8)	18 (12.1)	1.08 (0.61-1.83)	.79
Instability	58 (5.57)	6 (4.03)	0.56 (0.19-1.32)	.23
Aseptic loosening	0 (0)	0	N/A	N/A

PPFX, periprosthetic fracture; *PJI*, prosthetic joint infection; *ESRD*, end-stage renal disease; *RT*, renal transplant; *OR*, odds ratio; *CI*, confidence interval.

Table VI
Surgical complications at 2 years.

	ESRD	RT	OR (95% CI)	*P* value
	N (%)	N (%)		
PPFX	51 (4.89)	4 (2.69)	0.53 (0.16-1.33)	.228
PJI	6 (0.58)	1 (0.67)	1.06 (0.05-7.74)	.96
Stiffness	137 (13.15)	19 (12.75)	0.97 (0.55-1.61)	.902
Instability	66 (6.33)	6 (4.03)	0.48 (0.16-1.13)	.131
Aseptic loosening	1 (0.1)	0	N/A	N/A

PPFX, periprosthetic fracture; *PJI*, prosthetic joint infection; *ESRD*, end-stage renal disease; *RT*, renal transplant; *OR*, odds ratio; *CI*, confidence interval.

Patient characteristics

Male patients made up a larger proportion of the RT cohort (53%) than the ESRD cohort (41.8%) ($P = .01$) (Table I). Overall, RT patients were younger than ESRD patients (aged 65 vs. 70.9 years, $P < .001$). Patients aged 40-49 (2.01% vs. 1.06%, $P = .01$), 50-59 (17.45% vs. 9.02%, $P = .002$), and 60-69 years (42.28% vs. 27.06%, $P < .001$) made up a larger proportion of the RT cohort than the ESRD cohort (Table I). Patients aged 70-79 years (52.5% vs. 34.9%, $P < .001$) and 80+ years (8.35% vs. 0.67%, $P = .001$) made up a larger proportion of the ESRD cohort than the RT cohort (Table I). Patients with 2 CCIs accounted for a larger proportion of the RT cohort (12.08%) than the ESRD cohort (5.85%) ($P = .007$) (Table I).

Baseline medical comorbidities

ESRD patients were more likely to have hypertension (86.56% vs. 78.52%, $P = .012$), coronary artery disease (32.82% vs. 23.49%, $P = .028$), hypothyroidism (26.2% vs. 14.09%, $P = .002$), and valvular disease (18.62% vs. 8.72%, $P = .004$) within 1 year of index SA compared to RT patients. RT patients were more likely to have liver disease within 1 year of index SA compared to ESRD patients (14.09% vs. 7.39%, $P = .009$) (Table II).

Systemic and surgical complications

After controlling for age, gender, CCI, diabetes mellitus, and other index comorbidities identified as significantly different in univariate analysis, there was no significant difference in systemic complications (cardiac arrest, DVT, pneumonia, transfusion, pulmonary embolism, UTI, sepsis, reintubation, disruption of wound, hematoma) at 90 days between the ESRD and RT cohorts (Table III). There was also no significant difference in surgical complications (PPF, PJI, stiffness, instability, AL) at 90 days (Table IV), 1 year (Table V), or 2 years (Table VI) between ESRD and RT cohorts.

Discussion

With medical advances and increased success of maintenance treatment for ESRD and RT, there will continue to be a rise in the number of these patients undergoing SA.[7,12] THA and TKA have been studied extensively, comparing results between both the RT and ESRD patient population.[9,17,25,26,28,31,34-36] Li et al's meta-analysis of 10 studies and 6904 patients showed that RT patients had a lower risk of mortality, revision surgeries, and PJIs compared to ESRD patients when undergoing THA or TKA.[26] Chou et al's[7] meta-analysis which included 22 studies and 9384 patients undergoing THA or TKA showed a slightly increased mortality rate, surgical site complication, and PJI, however all without a significant trend, when comparing ESRD patients to RT patients. Lieu et al's[27] study looked at THA in 128 ESRD and 406 RT patients and showed that ESRD patients had twice the infection rates, higher rates of mortality, AL, and hip dislocations. Lieberman et al[25] looked at 30 patients and found that ESRD patients had poor results and an infection rate of 19%; however, there was no analysis done to indicate a significant trend. Shrader et al[41] showed that in patients undergoing THA, RT patients had higher cumulative rates of revisions and complications when compared to ESRD patients. This is most likely secondary to them having only 37 patients.

Currently, there are no studies available comparing medical complications between RT patients receiving SA and ESRD patients receiving SA. However, there are a few studies that studied SA in ESRD and RT separately. Schwartz et al[40] showed that ESRD patients had an increased risk of developing UTIs, DVT, C. diff infections, strokes, and myocardial infarctions in the postoperative period after SA when compared to patients without ESRD. These patients have an immunocompromised status, a decreased renal clearance, and electrolyte abnormalities, all of which increase their risk of developing postoperative complications.[3,28,40] In our study, there was no significant difference between the ESRD and RT patient cohorts and systemic complications at the 30-day mark. Schwartz et al[40] also found an increased risk of transfusions in

ESRD patients which they attribute to platelet dysfunction secondary to uremia.[23] We did not find an increased risk of transfusion when comparing ESRD and RT patients in our study. Because of their immunocompromised states and poor wound healing abilities, both ESRD and RT patients are also at an increased risk of surgical complications compared to patients with normal renal function.[15,28,40] Hatta et al[15] found an increased risk of PPF in solid-organ transplantation patients, without a significant difference in PJI or shoulder functional outcomes scorers. They hypothesized that the use of corticosteroids post-transplant, metabolic bone disease, and altered vitamin D metabolism all play a role in the risk of PPF.[1] However, their study only had 25 post-transplant patients. There was no increased risk of PPF or PJI among our cohort of 150 RT patients when compared to ESRD patients undergoing SA. Given that ESRD patients require hemodialysis with repeated vascular access, some studies have shown that these patients have higher rates of bacteremia, increasing their risk of PJI.[3,42] When compared to RT patients in our study, there was no increased risk of PJI in ESRD patients.

Our regression analysis did not show a significant trend favoring RT over ESRD patients with regards to stiffness, instability, AL, or PJI or fractures. It is difficult to delineate the variation found in our study compared to other studies. One of the main reasons is the difficulty in matching demographic characteristics of ESRD and RT patients.[34] Generally, RT patients are known to be younger and healthier than ESRD patients.[9,12,34] As such, could the poorer results among ESRD patients be confounded by their demographic characteristics of having more comorbidities and being generally older than RT patients? This may be the case because the above-mentioned studies that concluded more complications among ESRD patients in arthroplasty procedures did not allude to any attempts at decreasing confounding factors of these demographic characteristics (ie, through their regression model).[13,34,36,38] Only Chou et al[7] mentioned performing multiregression analysis, which yielded no significant trends. In the future, studies should focus on matching these 2 patient cohorts to decrease any confounding bias. Some authors have recommended that patients with ESRD should wait for kidney transplantation before receiving arthroplasty surgery.[22,48] The data presented here should act as a reference for surgeons and physicians in counseling both ESRD and RT patients regarding risks and benefits for undergoing SA. In addition to metabolic bone disease, both RT and ESRD are at higher risk of osteonecrosis of the humeral secondary to their chronic immunosuppression through steroids.[36] Providers should also consider holding these drugs prior to proceeding with SA procedures because of the increased risk of PJI in these patient populations.

There are limitations to this study. First, the study was a large database study and individualized patient information was not available, such as operative time, cement use, antibiotic use, types of implants, and perioperative imaging. One of these is whether a patient received an reverse TSA or TSA. Perhaps the revisions or infections only occurred in one versus the other. Another limitation is the length of follow-up. Given the life span of implants, a longer period of follow-up is required to observe any other postoperative changes/complications. Because ICD-9 and ICD-10 coding practices are not standardized, there is the risk of coding errors. Specifically, prior to 2010, all TSAs and reverse TSAs share the same procedure code.

Conclusion

Our present study is one of the largest comparing postoperative complications among RT and ESRD patients undergoing SA. Although previous studies have demonstrated difference between RT and ESRD patients, these differences may be the result of confounding of different comorbidities. There was no significant difference among rates of surgical and medical complications postoperatively between RT and ESRD patients. Although there is a known increased rate of complications among RT and ESRD patients individually, we did not find increased postoperative risks when comparing the 2 populations. When counseling RT and ESRD patients undergoing SA surgery, providers should still discuss the increased risk of postoperative complication in both these populations.

Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: Alexandra Stavrakis is a paid consult for Smith & Nephew and is a board member of AAHKS. The other 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.

References

1. Aminata I, Lee SH, Chang JS, Lee CS, Chun JM, Park JW, et al. Perioperative morbidity and mortality of total hip replacement in liver transplant recipients: a 7-year single-center experience. Transplantation 2012;94:1154-9. https://doi.org/10.1097/TP.0b013e31826ec713.
2. Browne J, Casp A, Cancienne JM, Werner BC. Peritoneal dialysis Does not Carry the same risk as hemodialysis in patients undergoing hip or knee arthroplasty. J Bone Joint Surg Am 2019;101:1271-7. https://doi.org/10.2106/JBJS.18.00936.
3. Cancienne JM, Kew ME, Deasey MJ, Brockmeier SF, Werner BC. Dialysis dependence and modality impact complication rates after shoulder arthroplasty. J Shoulder Elbow Surg 2019;28:e71-7. https://doi.org/10.1016/j.jse.2018.08.031.
4. Carminatti M, Tedesco-Silva H, Silva Fernandes NM, Sanders-Pinheiro H. Chronic kidney disease progression in kidney transplant recipients: a focus on traditional risk factors. Nephrology (Carlton) 2019;24:141-7. https://doi.org/10.1111/nep.13483.
5. Chalmers PN, Gupta AK, Rahman Z, Bruce B, Romeo AA, Nicholson GP. Predictors of Early complications of total shoulder arthroplasty. J Arthroplasty 2014;29:856-60. https://doi.org/10.1016/j.arth.2013.07.002.
6. Chang JS, Han DJ, Park SK, Sung JH, Ha YC. Cementless total hip arthroplasty in patients with osteonecrosis after kidney transplantation. J Arthroplasty 2013;28(5):824-7. https://doi.org/10.1016/j.arth.2013.01.020.
7. Chou TFA, Ma HH, Tsai SW, Chen CF, Wu PK, Chen WM. Dialysis patients have comparable results to patients who have received kidney transplant after total joint arthroplasty: a systematic review and meta-analysis. EFORT Open Rev 2021;6(8):618-28. https://doi.org/10.1302/2058-5241.6.200116.
8. Day JS, Lau E, Ong KL, Williams GR, Ramsey ML, Kurtz SM. Prevalence and projections of total shoulder and elbow arthroplasty in the United States to 2015. J Shoulder Elbow Surg 2010;19(8):1115-20. https://doi.org/10.1016/j.jse.2010.02.009.
9. Deegan BF, Richard RD, Bowen TR, Perkins RM, Graham JH, Foltzer MA. Impact of chronic kidney disease stage on lower-extremity arthroplasty. Orthopedics 2014;37(7):e613-8. https://doi.org/10.3928/01477447-20140626-51.
10. Erkocak OF, Yoo JY, Restrepo C, Maltenfort MG, Parvizi J. Incidence of infection and Inhospital mortality in patients with chronic renal failure after total joint arthroplasty. J Arthroplasty 2016;31(11):2437-41. https://doi.org/10.1016/j.arth.2016.04.031.
11. Getz CL, Kearns KA, Padegimas EM, Johnston PS, Lazarus MD, Williams GR. Survivorship of hemiarthroplasty with Concentric glenoid Reaming for glenohumeral arthritis in Young, active patients with a Biconcave glenoid. J Am Acad Orthop Surg 2017;25(10):715-23. https://doi.org/10.5435/JAAOS-D-16-00019.
12. Ghanta M, Jim B. Renal transplantation in advanced chronic kidney disease patients. Med Clin North Am 2016;100(3):465-76. https://doi.org/10.1016/j.mcna.2015.12.003.
13. Gilmer BB, Comstock BA, Jette JL, Warme WJ, Jackins SE, Matsen FA. The prognosis for improvement in comfort and function after the ream-and-run arthroplasty for glenohumeral arthritis: an analysis of 176 consecutive cases. J Bone Joint Surg Am 2012;94(14):e102. https://doi.org/10.2106/JBJS.K.00486.
14. Godenèche A, Boileau P, Favard L, Le Huec J-C, Lévigne C, Nové-Josserand L, et al. Prosthetic replacement in the treatment of osteoarthritis of the shoulder: Early results of 208 cases. J Shoulder Elbow Surg 2002;11:11-8. https://doi.org/10.1067/mse.2002.120140.
15. Hatta T, Statz JM, Itoi E, Cofield RH, Sperling JW, Morrey ME. Shoulder arthroplasty in patients with immunosuppression following solid organ

transplantation. J Shoulder Elbow Surg 2020;29(1):44-9. https://doi.org/10.1016/j.jse.2019.05.042.
16. Hernigou P, Hernigou J, Scarlat M. Shoulder osteonecrosis: pathogenesis, causes, clinical evaluation, imaging, and classification. Orthop Surg 2020;12(5):1340-9. https://doi.org/10.1111/os.12788.
17. Inoue D, Yazdi H, Goswami K, Tan TL, Parvizi J. Comparison of postoperative complications and Survivorship of total hip and knee arthroplasty in dialysis and renal transplantation patients. J Arthroplasty 2020;35(4):971-5. https://doi.org/10.1016/j.arth.2019.10.038.
18. Izquierdo R, Voloshin I, Edwards S, Freehill MQ, Stanwood W, Wiater JM, et al. Treatment of glenohumeral osteoarthritis. J Am Acad Orthop Surg 2010;18(6):375-82. https://doi.org/10.5435/00124635-201006000-00010.
19. Jiang JJ, Toor AS, Shi LL, Koh JL. Analysis of perioperative complications in patients after total shoulder arthroplasty and reverse total shoulder arthroplasty. J Shoulder Elbow Surg 2014;23(12):1852-9. https://doi.org/10.1016/j.jse.2014.04.008.
20. Jobin CM, Brown GD, Bahu MJ, Gardner TR, Bigliani LU, Levine WN, et al. Reverse total shoulder arthroplasty for cuff tear arthropathy: the clinical effect of deltoid lengthening and center of rotation medialization. J Shoulder Elbow Surg 2012;21(10):1269-77. https://doi.org/10.1016/j.jse.2011.08.049.
21. Kim SH, Wise BL, Zhang Y, Szabo RM. Increasing incidence of shoulder arthroplasty in the United States. J Bone Joint Surg Am 2011;93(24):2249-54. https://doi.org/10.2106/JBJS.J.01994.
22. Kuo LT, Lin SJ, Chen CL, Yu PA, Hsu WH, Chen TH. Chronic kidney disease is associated with a risk of higher mortality following total knee arthroplasty in diabetic patients: a nationwide population-based study. Oncotarget 2017;8:100288-95. https://doi.org/10.18632/oncotarget.22215.
23. Lambert MP. Platelets in liver and renal disease. Hematology 2016;2016(1):251-5. https://doi.org/10.1182/asheducation-2016.1.251.
24. Ledford CK, Watters TS, Wellman SS, Attarian DE, Bolognesi MP. Risk versus Reward: total joint arthroplasty outcomes after various solid organ transplantations. J Arthroplasty 2014;29(8):1548-52. https://doi.org/10.1016/j.arth.2014.03.027.
25. Lieberman JR, Fuchs MD, Haas SB, Gravin KL, Goldstock L, Gupta R, et al. Hip arthroplasty in patients with chronic renal failure. J Arthroplasty 1995;10:191-5.
26. Li J, Li M, Peng BQ, Luo R, Chen Q, Huang X. Comparison of total joint arthroplasty outcomes between renal transplant patients and dialysis patients—a meta-analysis and systematic review. J Orthop Surg Res 2020;15(1):590. https://doi.org/10.1186/s13018-020-02117-3.
27. Lieu D, Harris IA, Naylor JM, Mittal R. Review article: total hip replacement in haemodialysis or renal transplant patients. J Orthop Surg 2014;22(3):393-8. https://doi.org/10.1177/230949901402200325.
28. Lin MH, Lin SJ, Kuo LT, Chen TH, Chen CL, Yu PA, et al. Chronic kidney disease is associated with high mortality risk in patients with diabetes after primary shoulder arthroplasty: a nationwide population-based cohort study. Diagnostics 2021;11(5):822. https://doi.org/10.3390/diagnostics11050822.
29. Lo IKY, Litchfield RB, Griffin S, Faber K, Patterson SD, Kirkley A. Quality-of-life outcome following hemiarthroplasty or total shoulder arthroplasty in patients with osteoarthritis: a prospective, randomized trial. J Bone Joint Surg Am 2005;87(10):2178-85. https://doi.org/10.2106/JBJS.D.02198.
30. Lung BE, Bisogno M, Kanjiya S, Komatsu DE, Wang ED. Early postoperative complications and discharge time in diabetic patients undergoing total shoulder arthroplasty. J Orthop Surg Res 2019;14:9. https://doi.org/10.1186/s13018-018-1051-3.
31. Malkani JA, Heimroth JC, Ong KL, Wilson H, Price M, Piuzzi NS, et al. Complications and readmission incidence following total hip arthroplasty in patients who have end-stage renal failure. J Arthroplasty 2020;35(3):794-800. https://doi.org/10.1016/j.arth.2019.10.042.
32. Mathew A, Devereaux PJ, O'Hare A, Tonelli M, Thiessen-Philbrook H, Nevis IFP, et al. Chronic kidney disease and postoperative mortality: a systematic review and meta-analysis. Kidney Int 2008;73(9):1069-81. https://doi.org/10.1038/ki.2008.29.
33. Menendez ME, Baker DK, Fryberger CT, Ponce BA. Predictors of extended length of stay after elective shoulder arthroplasty. J Shoulder Elbow Surg 2015;24(10):1527-33. https://doi.org/10.1016/j.jse.2015.02.014.
34. Naito M, Ogata K, Shiota E, Nakamoto M, Goya T. Hip arthroplasty in haemodialysis patients. J Bone Joint Surg Br 1994;76:428-31.
35. Pandya J, Johnson T, Low AK. Shoulder replacement for osteoarthritis: A review of surgical management. Maturitas 2018;108:71-6. https://doi.org/10.1016/j.maturitas.2017.11.013.
36. Ponnusamy KE, Jain A, Thakkar SC, Sterling RS, Skolasky RL, Khanuja HS. Inpatient mortality and morbidity for dialysis-dependent patients undergoing primary total hip or knee arthroplasty. J Bone Joint Surg Am 2015;97(16):1326-32. https://doi.org/10.2106/JBJS.N.01301.
37. Rizk P, Rizzi SA, Patel MK, Wright TW, Struk AM, Patrick M. Shoulder arthroplasty in solid organ transplant patients: a retrospective, match paired analysis. J Shoulder Elbow Surg 2020;29(12):2548-55. https://doi.org/10.1016/j.jse.2020.03.035.
38. Sakalkale DP, Hozack WJ, Rothman RH. Total hip arthroplasty in patients on long-term renal dialysis. J Arthroplasty 1999;14:571-5.
39. Sayed-Noor AS. Joint arthroplasties other than the hip in solid organ transplant recipients. Open Orthop J 2009;3:27-31. https://doi.org/10.2174/1874325000903010027.
40. Schwartz AM, Anastasio AT, Farley KX, Boden S, Wagner ER, Gottschalk MB. Complications and mortality in patients with chronic kidney disease undergoing total shoulder arthroplasty. Semin Arthroplast JSES 2020;30:96-103. https://doi.org/10.1053/j.sart.2020.05.001.
41. Shrader MW, Schall D, Parvizi J, McCarthy JT, Lewallen DG. Total hip arthroplasty in patients with renal failure. A Comparison between transplant and dialysis patients. J Arthroplasty 2006;21(3):324-9. https://doi.org/10.1016/j.arth.2005.07.008.
42. Sinnakirouchenan R, Holley JL. Peritoneal dialysis versus hemodialysis: risks, benefits, and access issues. Adv Chronic Kidney Dis 2011;18(6):428-32. https://doi.org/10.1053/j.ackd.2011.09.001.
43. Tannenbaum DA, Matthews LS, Grady-Benson JC. Infection around joint replacements in patients who have a renal or liver transplantation. J Bone Joint Surg Am 1997;79:36-43.
44. Toomey HE, Toomey SD. Hip arthroplasty in chronic dialysis patients. J Arthroplasty 1998;13:647-52.
45. Warth LC, Pugely AJ, Martin CT, Gao Y, Callaghan JJ. Total joint arthroplasty in patients with chronic renal disease: is it Worth the risk? J Arthroplasty 2015;30(9 Suppl):51-4. https://doi.org/10.1016/j.arth.2014.12.037.
46. Waterman BR, Dunn JC, Bader J, Urrea L, Schoenfeld AJ, Belmont PJ. Thirty-day morbidity and mortality after elective total shoulder arthroplasty: patient-based and surgical risk factors. J Shoulder Elbow Surg 2015;24(1):24-30. https://doi.org/10.1016/j.jse.2014.05.016.
47. Wattanakit K, Cushman M, Stehman-Breen C, Heckbert SR, Folsom AR. Chronic kidney disease increases risk for venous thromboembolism. J Am Soc Nephrol 2008;19(1):135-40. https://doi.org/10.1681/ASN.2007030308.
48. Wolfe RA, Ashby VB, Milford EL, Ojo AO, Ettenger RE, Agodoa LYC, et al. Comparison of mortality in all patients on dialysis, patients on dialysis Awaiting transplantation, and recipients of a First Cadaveric transplant. N Engl J Med 1999;341:1725-30.
49. You Y, Zhang Y, Qiang L, Sun Y, Zhang JX, Bou E, et al. Prevalence and risk factors for perioperative complications of CKD patients undergoing elective hip surgery. J Orthop Surg Res 2019;14:82. https://doi.org/10.1186/s13018-019-1118-9.