General Orthopaedics

EOR | volume 6 | August 2021
DOI: 10.1302/2058-5241.6.200116
www.efortopenreviews.org

EFORT open reviews

Dialysis patients have comparable results to patients who have received kidney transplant after total joint arthroplasty: a systematic review and meta-analysis

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- Patients with end-stage renal disease (ESRD) have inferior outcomes after hip and knee total joint arthroplasty (TJA), with higher risk for surgical site complications (SSC) and periprosthetic joint infection (PJI).
- We conducted a systematic review and meta-analysis regarding outcomes after hip and knee TJA in ESRD patients who have received dialysis or a kidney transplant (KT) using PubMed, MEDLINE, Cochrane Reviews, and Embase in order to: (1) determine the mortality and infection rate of TJA in patients receiving dialysis or KT and (2) to identify risk factors associated with the outcome.
- We included 22 studies and 9384 patients (dialysis, *n* = 8921, KT, *n* = 463). The overall mortality rate was 14.9% and was slightly higher in KT patients (dialysis vs. KT, 13.8% vs. 15.8%). The overall SSC rate was 3.4%, while dialysis and KT patients each had an incidence of 3.3% and 3.6%, respectively. For PJI, the overall rate was 3.9%, while the incidence for dialysis patients was 4.0% and for KT patients was 3.7%.
- Using multi-regression analysis, age, sex, the type of arthroplasty (knee or hip) performed, and the form of renal replacement therapy (dialysis or KT) were not significant risk factors.
- In patients on dialysis or who had received a KT, TJA is associated with a slight increase in mortality, SSC and PJI rates.

Keywords: complication; dialysis; kidney transplant; mortality; periprosthetic joint infection; renal transplant; total hip arthroplasty; total knee arthroplasty

Cite this article: *EFORT Open Rev* 2021;6:618-628.
DOI: 10.1302/2058-5241.6.200116

Introduction

End-stage renal disease (ESRD) continues to be a major health problem around the world.[1] Currently, dialysis and kidney transplant (KT) are two ways to manage ESRD. Patients with ESRD have an increased demand for arthroplasty surgery due to several risk factors such as morbid obesity, alcohol abuse, and poorly controlled diabetes.[2,3] In addition, these patients have been shown to have a higher mortality and morbidity rate following arthroplasty surgeries.[4] The higher risk is most likely multi-factorial, including complex comorbidities, renal osteodystrophy leading to increased bone turnover, and beta 2-microglobulin deposition around the prosthesis.[5] For patients under dialysis, there may be a higher risk of haematogenous spread of bacteria, ultimately leading to prosthetic joint infections (PJI). For patients who received a kidney transplant, there is an increased risk of infection and implant loosening. This increased risk can be attributed to the relative immunocompromised status of KT patients.[4] On the other hand, postoperative complications are also a serious concern for orthopaedic surgeons. In current literature, there are several reports assessing the outcomes of total joint arthroplasty (TJA) in dialysis and KT. However, most of the studies have a relatively small sample size or were conducted prior to 2000. With recent advancements in medical treatment of dialysis patients, most of the studies do not reflect current practice. The most recent meta-analysis was performed by Popat et al, but this study only included patients who underwent THA.[6] In this study, we performed a comprehensive review assessing the outcome of total knee arthroplasty (TKA) and total hip arthroplasty (THA) in patients who are currently receiving dialysis or have had a KT. Specifically, we reviewed literature published after the year 2000 to answer the following questions: (1) What is the mortality rate after TJA? (2) What is the rate of surgical site complications (SSC) and PJI? (3) What are the risks factors that predispose to mortality, SSC and PJI?

Methods

Three authors (TFC, SWT, HHM) performed a comprehensive search on databases including PubMed, MEDLINE, Cochrane Reviews, and Embase. All articles were independently screened by three authors (TFC, SWT, HHM) for titles, abstracts, and full texts. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement was used in order to conduct the search. We searched for articles evaluating the postoperative outcomes of THA and TKA in dialysis or KT patients. The following terms were used in variable combination: total hip arthroplasty/replacement, total knee arthroplasty/replacement, dialysis, and renal/kidney transplant. The search strategy is presented in Fig. 1. If there was disagreement amongst the authors, a fourth reviewer (WMC) was consulted and differences were resolved.

Inclusion and exclusion criteria

We identified original studies that presented data on patients under dialysis or patients who received KT and underwent THA or TKA. All of the reviewed studies were written in English. To present an updated analysis, studies that were conducted before January 2000 were excluded. Patients with other aetiologies, review articles, letters to the editor, expert opinion, and studies in which data were not obtainable were also excluded. The included studies are listed in Table 1. If there was disagreement amongst the authors, a fourth author (WMC) was consulted. If there was uncertainty regarding a study, the original authors were contacted for additional information.

Methodological quality

The included studies were assessed using the Newcastle–Ottawa quality assessment scale for cohort studies. Two senior orthopaedic surgeons (TFC, SWT) independently reviewed and critiqued each article. The scale was graded from 0 to 9, with 9 being the highest possible score. A study was defined as ‘good’ if the total score was 7–9, as ‘fair’ if the score was 4–6, and a score of 4 or less was considered to be ‘poor’ (Table 2). If there were disagreements, a third author (HHM) was consulted.

Data extraction

Three authors (TFC, SWT, HHM) examined all the identified studies and extracted data using a predetermined form. The main objective was to determine the overall mortality, SSC and PJI rate in patients under dialysis or KT recipients after THA or TKA. We recorded the first author, year of publication, study design, type of renal replacement therapy (dialysis or KT), type of arthroplasty (TKA or THA), case number, age and follow-up duration as shown in Table 1. Patients who received either haemodialysis or

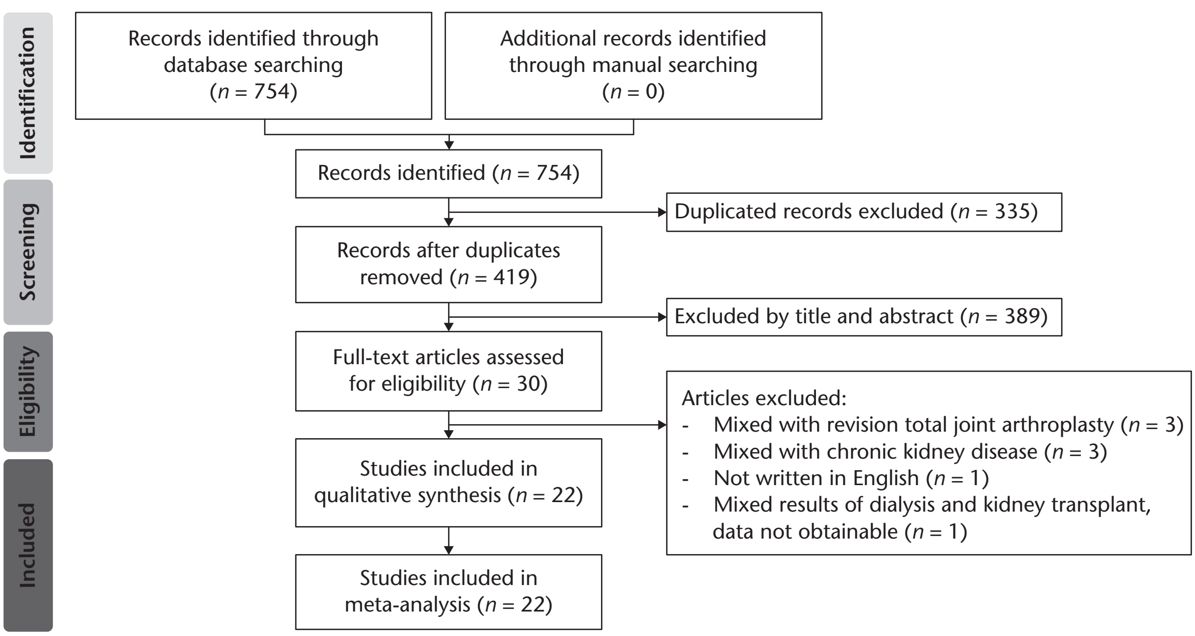

Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram for the searching and identification of included studies.

Table 1. Characteristics of included studies

Author, year	Study design	Dialysis or KT	TKA/THA	Mean age (years)	Follow-up duration (months)	Outcome measurements		
						A	B	C
Wang, 2019[10]	Retrospective case series	Dialysis	286/232	63.3	3.0	V		
Malkani, 2020[21]	Retrospective case series	Dialysis	0/301	N/A	60.0	V		V
		KT	0/94	N/A	60.0	V		V
Lo, 2019[2]	Retrospective case series	Dialysis	39/31	65.9	55.9	V	V	V
Labaran, 2019[5]	Retrospective case series	Dialysis	930/849	N/A	12.0	V		V
Browne, 2019[4]	Retrospective case series	Dialysis	1062/1144	N/A	12.0	V		V
Inoue, 2020[3]	Retrospective case series	Dialysis	50 TJA	60.9	72.5		V	V
		KT	57 TJA	62.9	52.5		V	V
Yen, 2018[27]	Retrospective case series	Dialysis	26/0	66.0	66.0	V	V	V
Patterson, 2018[24]	Retrospective case series	Dialysis	339/306	N/A	1.0		V	V
Ottesen, 2018[23]	Retrospective case series	Dialysis	250/0	68.0	1.0		V	V
Erkocak, 2016[15]	Retrospective case series	Dialysis	50 TJA	N/A	1.0		V	V
Ponnusamy, 2015[25]	Retrospective case series	Dialysis	1683/1251	66.7/63.2	Inpatient, <1 month		V	V
Ledford, 2014[18]	Retrospective case series	KT	12/25	52.4	36.5	V	V	V
Chen, 2014[14]	Retrospective case series	Dialysis	18/0	75.8	25.0	V	V	V
Chang, 2013[13]	Retrospective case series	KT	0/74	42.1	122.4	V	V	V
Lim, 2012[20]	Retrospective case series	KT	0/45	44.0	86.4		V	V
Li, 2010[19]	Retrospective case series	Dialysis	0/23	66.0	7.0	V	V	V
Fukunishi, 2009[16]	Retrospective case series	Dialysis	0/19	56.0	45.2	V	V	V
Garcia-Ramiro, 2008[17]	Retrospective case series	Dialysis	0/12	62.7	46.5	V	V	V
		KT	0/11 (including hemiarthroplasty)	51.2	73.9	V	V	V
Boquet, 2008[12]	Retrospective case series	KT	16/0	63.0	65.0	V	V	
Shrader, 2006[26]	Retrospective case series	Dialysis	0/9	67.0	72.0	V	V	V
	Retrospective case series	KT	0/36	46.0	132.0	V	V	V
Goffin, 2006[11]	Retrospective case series	KT	0/93	38.0	216.0	V		V
Nagoya, 2005[22]	Retrospective case series	Dialysis	0/11	41.8	99.0	V	V	V

Notes. Outcome measures: A, description of mortality rate; B, description of surgical site complication; C, description of periprosthetic joint infection.

Dialysis, contains patients under hemodialysis and peritoneal dialysis; KT, kidney transplant patient; N/A, not available; THA, total hip arthroplasty; TKA, total knee arthroplasty; TJA, total joint arthroplasty.

peritoneal dialysis were both categorized under 'dialysis'. We also recorded the pooled mortality rate, SSC rate and PJI rate as shown in Table 3. SSC is defined as any wound complications such as haematoma, seroma, delayed wound healing, or superficial wound infection which required management such as intravenous antibiotic wound repair or surgical debridement.[7] PJI is generally defined based on the criteria developed by the Musculoskeletal Infection Society (MSIS) workgroup in the different study period.[8,9] Moreover, patients with PJI had a more severe type of infection that involved the bone and joint surface which required extensive debridement and/or resection of the prosthesis. The overall mortality rate includes the 30-day mortality rate, 90-day mortality rate or crude mortality rate as recorded by each study.

Statistical analysis

A meta-analysis of proportions was conducted using the Freeman–Tukey analysis under random-effects model to calculate pooled estimates with a 95% confidence interval. A random-effects model was used for differences among studies such as patient characteristics, type of arthroplasty surgery performed, type of renal replacement therapy, and study methodology. For potential factors that may affect mortality, SSC, and PJI, a standard multi-variable linear regression analysis (β) was performed. All statistical analyses were completed with the Comprehensive Meta-Analysis (CMA) software, version 3 (Biostat, Englewood, NJ, USA). Statistical significance was defined as a p-value < 0.05.

Results

Articles

After removing duplicate articles, there were 419 articles identified for review. After reviewing the remaining articles, 389 were excluded since they did not meet our inclusion criteria. After exclusion, a total of 22 articles and 9384 patients were included for this meta-analysis (Fig. 1).[2–5,10–27] If possible, the articles were then divided based on the site of arthroplasty surgery (TKA or THA) and the type of renal replacement therapy (dialysis vs. kidney transplant).

Baseline characteristics

A total of 22 articles (n = 9384) were reviewed for this study. The mean age of patients was 63.4 years and the

Table 2. Study assessment based on quality assessment tool for case series studies

Criteria	Wang et al, 2019[10]	Malkani et al, 2020[21]	Lo et al, 2019[2]	Labaran et al, 2019[5]	Browne et al, 2019[4]	Inoue et al, 2020[3]	Yen et al, 2018[27]	Patterson et al, 2018[24]	Ottesen et al, 2018[23]	Erkocak et al, 2016[15]
1. Was the study question or objective clearly stated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the study population clearly and fully described, including a case definition?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Were the cases consecutive?	N	N	N	N	N	N	N	N	N	N
4. Were the subjects comparable?	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
5. Was the intervention clearly described?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6. Were the outcome measures clearly defined, valid, reliable and implemented consistently across all study participants?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7. Was the length of follow-up adequate?	Y	Y	Y	Y	Y	Y	Y	N	N	N
8. Were the statistical methods well-described?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. Were the results well-described?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Quality of the cohort study (score)	7	8	8	8	8	8	8	7	7	6

Notes. Y, yes; N, no. The maximum possible score on this scale is 9. 'Good' was defined as a total score of 7–9; 'fair' as a score of 4–6, and 'poor' as a score of less than 4.

Criteria	Ponnusamy et al. 2015	Ledford et al. 2014	Chen et al. 2014	Chang et al. 2013	Lim et al. 2012	Li et al. 2010	Fukunishi et al. 2009	Garcia-Ramiro et al. 2008	Boquet et al. 2008	Shrader et al. 2006
1. Was the study question or objective clearly stated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the study population clearly and fully described, including a case definition?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Were the cases consecutive?	N	N	N	N	Y	Y	N	N	N	N
4. Were the subjects comparable?	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
5. Was the intervention clearly described?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6. Were the outcome measures clearly defined, valid, reliable and implemented consistently across all study participants?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

(continued)

Table 2. (continued)

Criteria	Ponnusamy et al. 2015	Ledford et al. 2014	Chen et al. 2014	Chang et al. 2013	Lim et al. 2012	Li et al. 2010	Fukunishi et al. 2009	Garcia-Ramiro et al. 2008	Boquet et al. 2008	Shrader et al. 2006
7. Was the length of follow-up adequate?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Were the statistical methods well-described?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. Were the results well-described?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Quality of the cohort study (score)	7	8	7	8	9	9	8	8	8	8

Y= Yes, N= No; The maximum possible score on this scale is 9. "Good" was defined as a total score of 7-9; "fair" as a score 4-6, and "poor" as a score of less than 4.

Criteria	Goffin et al. 2006	Nagoya et al. 2005
1. Was the study question or objective clearly stated?	Y	Y
2. Was the study population clearly and fully described, including a case definition?	Y	Y
3. Were the cases consecutive?	Y	Y
4. Were the subjects comparable?	Y	Y
5. Was the intervention clearly described?	Y	Y
6. Were the outcome measures clearly defined, valid, reliable and implemented consistently across all study participants?	Y	Y
7. Was the length of follow-up adequate?	Y	Y
8. Were the statistical methods well-described?	Y	Y
9. Were the results well-described?	Y	Y
Quality of the cohort study (score)	9	9

Y= Yes, N= No; The maximum possible score on this scale is 9. "Good" was defined as a total score of 7-9; "fair" as a score 4-6, and "poor" as a score of less than 4.

mean follow-up duration was 20.4 months (range: 1 to 216 months). Of the 9384 patients, 8921 patients were under dialysis, while 463 patients had received a KT.

Overall mortality rate

There were 16 studies (n = 5353) that recorded the mortality rate after TJA.[2,4,5,10–14,16–19,21,22,26,27] The overall pooled mortality rate in dialysis-dependent and KT patients who received TJA was 14.9% (95% CI: 0.092–0.231). For patients who are under dialysis, the pooled mortality rate was 13.8% (95% CI: 0.067–0.264). On the other hand, patients who had received a KT had a mortality rate of 15.8% (95% CI: 0.083 – 0.281) (Fig. 2).

Surgical site complication rate (SSC)

There were 17 studies (N = 4381) that recorded the SSC rate after TJA.[2,3,5,12-17,19,20,22-27] The overall pooled SSC rate in dialysis-dependent and KT patients who received TJA was 3.4% (95% CI: 0.023–0.050). For patients who are under dialysis, the pooled SSC rate was 3.3% (95% CI: 0.021–0.052).

Table 3. Pooled mortality, periprosthetic joint infection and surgical site complication rate

	Rate	95% Confidence interval
Mortality	0.149	0.092–0.231
Dialysis	0.138	0.067–0.264
Kidney transplant	0.158	0.083–0.281
Surgical site complication	0.034	0.023–0.050
Dialysis	0.033	0.021–0.052
TKA	0.020	0.015–0.027
THA	0.035	0.027–0.045
Kidney transplant	0.036	0.017–0.074
TKA	0.063	0.009–0.335
THA	0.037	0.016–0.083
Periprosthetic joint infection	0.039	0.019–0.080
Dialysis	0.040	0.016–0.098
TKA	0.034	0.009–0.124
THA	0.041	0.017–0.094
Kidney transplant	0.037	0.010–0.122
TKA	0.083	0.012–0.413
THA	0.031	0.005–0.160

Notes. THA, total hip arthroplasty; TKA, total knee arthroplasty.

Meanwhile, patients who had received a KT had an SSC rate of 3.6% (95% CI: 0.017–0.074) (Fig. 3).

Periprosthetic joint infection rate (PJI)

There were 20 studies (*N* = 8825) that recorded the PJI rate after TJA.[2-5,12-27] The overall pooled PJI rate in dialysis-dependent and KT patients who received TJA was 3.9% (CI: 0.019–0.080). For patients who are under dialysis, the pooled PJI rate was 4.0% (CI: 0.016–0.098). For patients who had received a KT, the pooled PJI rate was 3.7% (CI: 0.010–0.122) (Fig. 4).

Risk factors that predispose to mortality, SSC and PJI

The regression analysis revealed age, gender and the type of arthroplasty received did not significantly increase the risk for mortality, SSC and PJI. Notably, type of renal replacement therapy (dialysis or KT) was not a risk factor for mortality, SSC and PJI (Table 4).

Discussion

In this study, we present a comprehensive review of total joint arthroplasty (TJA) in patients with ESRD who are currently under dialysis treatment or have received a KT. Several risk factors affect the outcome of TJA, and ESRD has been associated with increased complications following TJA.[28] In comparison with patients who have normal renal function, ESRD has been shown to increase the risk of mortality, re-admission, surgical site infection, and perioperative transfusion.[28] In patients under dialysis or who have received a KT, other complications such as haematogenous spreading of bacteria, catheter-related infections and opportunistic infections may occur.[2,21]

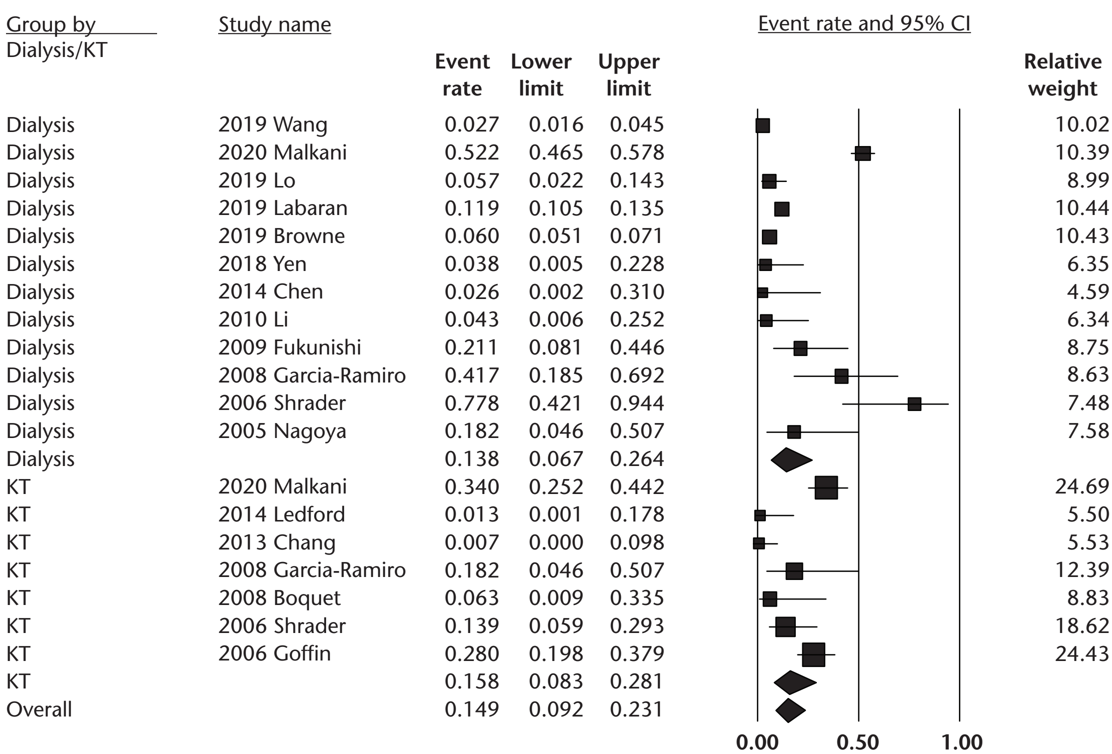

Fig. 2 Forest plot of the pooled mortality rate among included studies.
Note. KT, kidney transplant.

Group by Dialysis/KT	Study name	Event rate	Lower limit	Upper limit	Relative weight
Dialysis	2019 Lo	0.007	0.000	0.103	2.57
Dialysis	2020 Inoue	0.060	0.019	0.170	9.77
Dialysis	2018 Yen	0.038	0.005	0.228	4.53
Dialysis	2018 Patterson	0.014	0.007	0.027	16.52
Dialysis	2018 Ottesen	0.020	0.008	0.047	13.10
Dialysis	2016 Erkocak	0.120	0.055	0.242	13.55
Dialysis	2015 Ponnusamy	0.028	0.022	0.034	23.11
Dialysis	2014 Chen	0.026	0.002	0.310	2.53
Dialysis	2010 Li	0.021	0.001	0.259	2.54
Dialysis	2009 Fukunishi	0.025	0.002	0.298	2.53
Dialysis	2008 Garcia-Ramiro	0.038	0.002	0.403	2.50
Dialysis	2006 Shrader	0.111	0.015	0.500	4.25
Dialysis	2005 Nagoya	0.042	0.003	0.425	2.49
Dialysis		0.033	0.021	0.052	
KT	2020 Inoue	0.009	0.001	0.123	7.40
KT	2014 Ledford	0.019	0.001	0.244	7.32
KT	2013 Chang	0.007	0.000	0.098	7.41
KT	2012 Lim	0.044	0.011	0.161	28.53
KT	2008 Garcia-Ramiro	0.042	0.003	0.425	7.15
KT	2008 Boquet	0.063	0.009	0.335	13.99
KT	2006 Shrader	0.056	0.014	0.197	28.19
KT		0.036	0.017	0.074	
Overall		0.034	0.023	0.050	

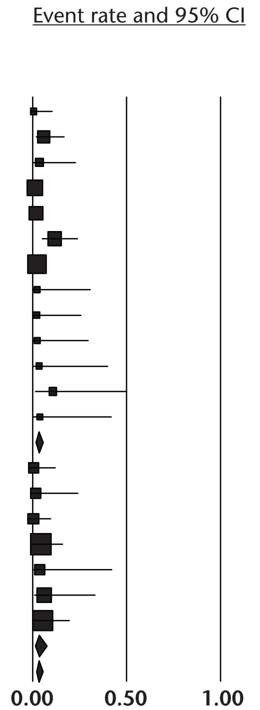

Fig. 3 Forest plot of the pooled surgical site complication rate among included studies.
Note. KT, kidney transplant.

Group by Dialysis/KT	Study name	Statistics for each study: Event rate	Lower limit	Upper limit	Relative weight
Dialysis	2020 Malkani	0.070	0.046	0.105	7.67
Dialysis	2019 Lo	0.043	0.014	0.125	6.99
Dialysis	2019 Labaran	0.292	0.271	0.313	7.79
Dialysis	2020 Inoue	0.180	0.096	0.311	7.47
Dialysis	2019 Browne	0.038	0.030	0.046	7.77
Dialysis	2018 Yen	0.019	0.001	0.236	4.65
Dialysis	2018 Patterson	0.002	0.000	0.011	5.85
Dialysis	2018 Ottesen	0.004	0.001	0.028	5.85
Dialysis	2016 Erkocak	0.080	0.030	0.195	7.16
Dialysis	2015 Ponnusamy	0.011	0.007	0.015	7.72
Dialysis	2014 Chen	0.026	0.002	0.310	4.64
Dialysis	2010 Li	0.021	0.001	0.259	4.65
Dialysis	2009 Fukunishi	0.053	0.007	0.294	5.78
Dialysis	2008 Garcia-Ramiro	0.083	0.012	0.413	5.73
Dialysis	2006 Shrader	0.111	0.015	0.500	5.68
Dialysis	2005 Nagoya	0.042	0.003	0.425	4.61
Dialysis		0.040	0.016	0.098	
KT	2020 Malkani	0.011	0.001	0.072	12.37
KT	2020 Inoue	0.035	0.009	0.130	14.40
KT	2014 Ledford	0.083	0.012	0.413	12.10
KT	2013 Chang	0.007	0.000	0.098	9.62
KT	2012 Lim	0.011	0.001	0.151	9.60
KT	2008 Garcia-Ramiro	0.455	0.203	0.732	15.17
KT	2006 Shrader	0.028	0.004	0.173	12.31
KT	2006 Goffin	0.022	0.005	0.082	14.44
KT		0.037	0.010	0.122	
Overall		0.039	0.019	0.080	

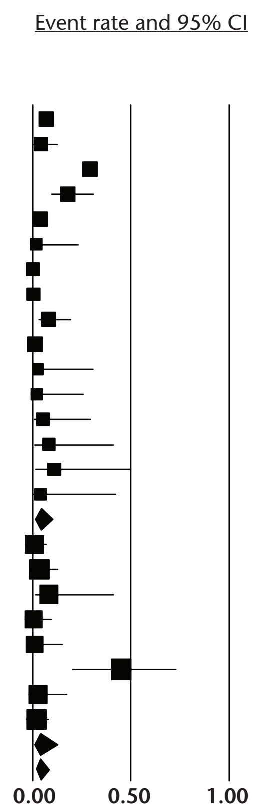

Fig. 4 Forest plot of the pooled periprosthetic joint infection rate among included studies.
Note. KT, kidney transplant.

Table 4. Multi-variate linear regression analysis

Independent variable	β coefficient	95% confidence interval	P-value
Mortality			
Age	0.00	–0.12–0.11	0.949
Female sex	–1.25	–4.20–1.70	0.406
Surgery (THA ref to TKA)	0.82	–1.15–2.80	0.415
Dialysis (ref to KT)	–0.64	–2.78–1.50	0.560
Surgical site complications			
Age	–0.01	–0.11–0.10	0.864
Female sex	–0.55	–2.89–1.79	0.646
Surgery (THA ref to TKA)	–0.41	–2.17–1.35	0.650
Dialysis (ref to KT)	–0.29	–1.86–1.27	0.713
Periprosthetic joint infection			
Age	0.05	–0.08–0.18	0.439
Female sex	0.01	–3.26–3.28	0.996
Surgery (THA ref to TKA)	0.34	–1.94–2.63	0.769
Dialysis (ref to KT)	0.28	–2.00–2.56	0.810

Notes. KT, kidney transplant; THA, total hip arthroplasty; TKA, total knee arthroplasty.

In a comprehensive review performed by Browne et al, the authors noted that dialysis-dependent patients have an increased risk for infection and bacteremia following THA and TKA.[4] In another review, KT patients were more likely to have postoperative infections due to their relatively immune-deficient status.[4] In recent years, some authors have recommended that patients with ESRD who are currently under haemodialysis (HD) should wait for kidney transplantation before receiving arthroplasty surgery.[3] However, other studies had less promising results and the appropriate management is still inconclusive.[17,26] Moreover, not all patients are candidates for renal transplant and the risks and benefits should be evaluated. The most recent meta-analysis comparing the outcome of TJA in these two renal replacement modalities was performed by Lieu et al.[29] However, most of the included studies were performed prior to 2003 and focused only on total hip arthroplasty. With recent advancements in medical management of post-transplant patients, an updated analysis is necessary to determine the appropriate treatment.[30] Upon reviewing 22 well-designed studies, we noted a relatively higher overall mortality (14.9%; CI: 0.092–0.231), SSC (3.4%; CI: 0.023–0.050) and PJI (3.9%; CI: 0.019–0.080) rate in patients with ESRD.[2–5,10–27] When evaluating the patients based on type of renal replacement therapy, there was an increase in mortality rate after TJA in patients under dialysis (13.8%; CI: 0.067–0.264) and patients who had previously received a KT (15.8%; CI: 0.083–0.281). Several reports have discussed the mortality rate after TJA in this patient population.[2,4,5,10–14,16–19,21,22,26,27] In a case-control study performed by Erkocak et al, the authors noted a significantly higher odds ratio (*OR* = 10.46) for in-hospital mortality in patients under dialysis in comparison with non-ESRD patients.[15] In the general population, the in-hospital mortality rate is relatively low, with an incidence of 0.13% and 0.18% after TKA and THA respectively.[31] This increase in mortality rate in dialysis patients after TJA is multi-factorial.[15,32] First, there is a significant increase in cardiovascular events in ESRD patients under dialysis, leading to sudden cardiac arrest and congestive heart failure.[32] Since TJA represents a significant amount of stress for selective patients (e.g. patients with previous cardiovascular events, ESRD, age of > 80 years), ESRD patients will inevitably have a higher risk for postoperative cardiovascular morbidities.[33] In addition, complex infections (e.g. catheter-related infections) and chronic systemic inflammation also increase mortality in these patients.[32] On the other hand, renal transplant patients also have an increased mortality rate after TJA compared with the general population.[21] In particular, the chronic usage of immunosuppressants and steroids puts these patients at risk for cardiovascular diseases, infection and steroid-related complications.[20,34] Interestingly, in several comprehensive studies comparing mortality rates for patients with dialysis or KT, there was a significant reduction in mortality rate for patients who had received a KT.[3,21] Malkani et al also noted lower mortality rates in KT patients who underwent THA, with an adjusted mortality of 29 per 1000 patients in comparison with 164 per 1000 patients for dialysis patients.[21] The higher mortality noted in our study for KT patients can be explained by several factors. First, Inoue et al identified that TKA was an independent risk factor for complications when compared with THA.[3] Our study included both TKA and THA surgeries which may have affected the outcome. Moreover, most of the studies included in our review for KT patients were conducted between 2003 and 2013. Over the past decade, there has been significant improvement in post-transplant care, as multiple immunosuppressants such as antiproliferative drugs have been used widely, which may have reduced the overall mortality rate.[34,35] In addition, identifying and managing cardiovascular events have also contributed to a significant decrease in mortality rates amongst KT patients.[34] Nonetheless, ESRD patients who are on dialysis or have received a KT both carry an increased risk for mortality after TJA. Therefore, the surgeon should carefully evaluate the proper patient who can tolerate a TJA surgery.

Patients with ESRD are at risk for wound healing complications.[36] In our study, the pooled SSC rate was 3.4% (CI: 0.023–0.050). The higher incidence in these patients can be attributed to several factors. For instance, ESRD patients are at risk for bleeding due to platelet dysfunction and chronic use of anticoagulants.[37,38] In a comprehensive study by Ponnusamy et al, dialysis patients were more likely to experience wound haematoma, seroma and infection.[25] Despite recent advancements in postoperative management for transplant patients, wound healing continues to be a major challenge for physicians.[35,39] In this study, the SSC rates in both dialysis (3.3%) and KT (3.6%) patients were high. Several studies have evaluated the mechanisms that affect wound healing in KT patients. First, several chronic immunosuppressants (e.g. steroids, sirolimus, everolimus) have antiproliferative properties that directly impair the wound healing pathway.[35] In addition, post-transplant blood disorders (e.g. platelet dysfunction, acute myeloid leukaemia etc.) and higher infection rates all predispose these patients to wound complications.[40] Currently, there are very few reports discussing the management of wound complications after TJA in this patient population. Røine et al evaluated the risk factors that may predispose surgical wound complications after kidney transplant.[35] In particular, the authors recommended placement of subcutaneous sutures and insertion of a drain to prevent persistent wound leakage.[35] Future studies should target the management of postoperative wound complications, specifically orthopaedic procedures such as TJA, for this cohort.

Periprosthetic joint infection is one of the most devastating complications after TJA. The incidence of infection after TJA is around 0.5%~2% for the general population.[41,42] Since infection is the second leading cause of death in patients on dialysis or who have received a KT, it is essential for orthopaedic surgeons to identify all modifiable risks in this population.[43,44] In this study, we defined a PJI as an infection with involvement of the bone–joint interface. Upon review of 22 articles, the pooled incidence rate for PJI was 3.9% (CI: 0.019–0.080). When we divided the patients based on the type of renal replacement therapy, we found higher incidence of PJI in both dialysis (4.0%) and KT (3.7%) patients (Table 3). Several factors predispose dialysis patients to infections. HD patients have a 25–50-fold increased risk for bacteremia, with Gram-positive bacteria causing a majority of the infections.[45] Many studies have related this higher incidence to catheter-related infections, as dialysis requires a chronic intravenous access either through a central catheter or a dialysis shunt.[44] Moreover, the risk for methicillin-resistant *Staphylococcus aureus* (MRSA) infections is significantly higher for dialysis patients.[44] MRSA is a well-recognized pathogen for PJI and is notorious for having significantly higher treatment failure rates.[46] The combination of immunodeficient status, and predisposition for MRSA infection have led several experts to advise against arthroplasty surgery for dialysis patients.[25] To avoid these catastrophic events, all modifiable risks such as creating a permanent arteriovenous fistula prior to surgery, empirical antibiotics with vancomycin or waiting for renal transplant have all been proposed by authors.[3,44] Interestingly, Browne et al assessed the outcome after TJA for patients on peritoneal dialysis (PD) and concluded that PD patients did not carry the same risk for bacteremia and that PD was associated with less systemic inflammation.[4] In our multi-regression analysis, we did not find type of renal replacement therapy (dialysis or KT) to be a risk factor for PJI, although the PJI rate was slightly higher in dialysis patients (dialysis vs. KT, 4.0% vs. 3.7%). Current literature also supports this trend, but there could be potential bias in these results. First, the baseline patient status for HD patients is often complicated with multiple comorbidities, making these patients less suitable for transplant surgery.[3] Their complicated patient status could potentially affect the outcome of dialysis patients after TJA. Future studies should include matched cohorts to remove potential confounding factors and to better delineate the differences between these two cohorts.

The final aim of this study was to identify potential risk factors that may lead to failure (Table 4). Specifically, we assessed the effects of age, sex, type of arthroplasty surgery (THA vs. TKA) and the type of renal replacement therapy (dialysis vs. KT). Interestingly, none of these factors appeared to have a significant effect on the rate of mortality, SSC and PJI. In the current literature, the effects of advanced age and gender on the outcome of TJA are well documented.[47,48] Fang et al reviewed 871 THAs and 921 TKAs and concluded increased age is associated with higher in-hospital complication rates and ICU utilization.[47] In a national database study performed by Robinson et al, the authors identified that female gender was a protective factor for sepsis, cardiovascular complications, and renal complications after TJA.[48] With regard to the type of arthroplasty surgery, George et al reviewed 248,150 primary THA/TKA procedures using the National Surgical Quality Improvement Project database. The 30-day rates of re-admission ($P < .001$) and re-operation ($P < .001$) were higher in THA.[49] The results from this study did not display similar trends to those described by other authors[46–48] and could be due to different patient characteristics (ESRD vs. all patients who had undergone TJA), and the heterogeneity of the included studies for this review. A recent highly debated topic is whether KT patients had better outcomes following TJA in comparison with dialysis patients. Our regression analysis did not show a significant trend favouring KT with regards to mortality, SSC or PJI rate. Therefore, the data presented in this study can be used as a reference for physicians to discuss with patients regarding the benefits and outcomes in this patient population. Moreover, the increased SSC and PJI rate in this patient population raises concerns such as whether certain drugs (immunosuppressants/antiproliferative drugs), should be withheld temporarily during the perioperative period. As with management of other types of systemic, complicated diseases, it is essential for orthopaedic surgeons to perform comprehensive preoperative studies and to thoroughly explain the higher rates of complications in this patient population.

This study is not without limitations. First, this study only included studies that were written in English, and most of the larger studies were conducted in the US and European countries. Therefore, the data should be interpreted with caution in regions of the world that may have different medical environments. In addition, some studies did not analyse THA and TKA as well as HD and PD as separate entities. In the current literature, there is growing evidence that the type of surgery and form of renal replacement therapy can affect the outcome.[4,49] Lastly, all included studies were retrospective cohort studies, which is considered to be a moderate level of evidence for systematic reviews. Additional, prospective studies that limit the confounders associated with different baseline patient characteristics (dialysis vs. KT patients) are required to draw conclusions about the effects of dialysis and KT on TJA.

Conclusions

The outcome of TJA remains inferior in patients on dialysis and patients who have received a KT. Interestingly, this study noted similar mortality, SSC and PJI rates between dialysis and KT patients. Our regression analysis of the type of renal replacement therapy further suggested that dialysis is not a risk factor for mortality, SSC, and PJI when compared with KT patients. These results can be used by the physician when discussing options with patients on renal replacement therapy who are considering a TJA procedure.

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ICMJE CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest relevant to this work.

FUNDING STATEMENT

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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