The Journal of Arthroplasty 35 (2020) 224–228

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Revision Arthroplasty

Revision Joint Arthroplasty and Renal Transplant: A Matched Control Cohort Study

Lawal A. Labaran, BS [a], Raj Amin, MD [b], Surajudeen A. Bolarinwa, MD [a], Varun Puvanesarajah, MD [b], Sandesh S. Rao, MD [a], James A. Browne, MD [a], Brian C. Werner, MD [a, *]

[a] Department of Orthopaedic Surgery, University of Virginia, Charlottesville, VA
[b] Department of Orthopaedic Surgery, Johns Hopkins Hospital, Baltimore, MD

ARTICLE INFO

Article history:
Received 18 June 2019
Received in revised form
17 August 2019
Accepted 20 August 2019
Available online 27 August 2019

Keywords:
renal transplant
kidney transplant
revision hip arthroplasty
revision knee arthroplasty
postoperative outcome
surgical site infection

ABSTRACT

Background: There is little literature concerning clinical outcomes following revision joint arthroplasty in solid organ transplant recipients. The aims of this study are to (1) analyze postoperative outcomes and mortality following revision hip and knee arthroplasty in renal transplant recipients (RTRs) compared to non-RTRs and (2) characterize common indications and types of revision procedures among RTRs.
Methods: A retrospective Medicare database review identified 1020 RTRs who underwent revision joint arthroplasty (359 revision total knee arthroplasty [TKA] and 661 revision total hip arthroplasty [THA]) from 2005 to 2014. RTRs were compared to their respective matched control groups of nontransplant revision arthroplasty patients for hospital length of stay, readmission, major medical complications, infections, septicemia, and mortality following revision.
Results: Renal transplantation was significantly associated with increased length of stay (6.12 ± 7.86 vs 4.33 ± 4.29, $P < .001$), septicemia (odds ratio [OR], 2.52; 95% confidence interval [CI], 1.83-3.46; $P < .001$), and 1-year mortality (OR, 2.71; 95% CI, 1.51-4.53; $P < .001$) following revision TKA. Among revision THA patients, RTR status was associated with increased hospital readmission (OR, 1.23; 95% CI, 1.03-1.47; $P =$ .023), septicemia (OR, 1.82; 95% CI, 1.41-2.34; $P < .001$), and 1-year mortality (OR, 2.65; 95% CI, 1.88-3.66; $P < .001$). The most frequent primary diagnoses associated with revision TKA and THA among RTRs were mechanical complications of prosthetic implant.
Conclusion: Prior renal transplantation among revision joint arthroplasty patients is associated with increased morbidity and mortality when compared to nontransplant recipients.

Total hip (THA) and knee arthroplasties (TKA) have been established as some of the most clinically successful and cost-effective surgical interventions for the treatment of degenerative joint diseases [1]. Approximately one million THA and TKA are performed annually in the United States [2]. As the incidence of joint arthroplasty continues to rise, so too has the number of revision joint procedures performed as approximately 50,000 revision hip [3] and 70,000 revision knee arthroplasties estimated to be performed annually in the United States by 2030. Given the improvements in the perioperative care of this patient population, the proportion of complex patients requiring revision total joint arthroplasty (TJA) is also expected to increase [4].

There are limited data regarding the outcomes of solid organ transplant (SOT) recipients in joint arthroplasty surgery. In primary joint arthroplasty, SOT recipients have been shown to have increased rates of morbidity and mortality [4–6]. Chalmers et al [6] reported that SOT recipients had increased mortality at 5 years and lower implant survivorship free of revision following primary THA compared to nontransplant patients. Klatt et al [5] reported an increased rate of infection among SOT patients undergoing a primary TJA within at least 2 years postoperatively.

Although SOT recipients have been shown to have higher rate of complications and lower survivorship following primary TJA [4–6], there are sparse data regarding the outcomes of revision joint

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2019.08.045.

* Reprint requests: Brian C. Werner, MD, Department of Orthopaedic Surgery, University of Virginia, 400 Ray C Hunt Drive, Charlottesville, VA 22908.

https://doi.org/10.1016/j.arth.2019.08.045
0883-5403/

arthroplasties in transplant recipients. While Ledford et al [7] highlighted clinical outcomes, complications, and patient survivorship of SOT recipients of kidney, liver, heart, and lung following revision TJA, this study was limited by a total sample size of 39 patients. Furthermore, pooling of patients receiving different types of transplants into a single study cohort may potentially affect the accuracy of results reported in contemporary studies due to the varying degree of complications associated with each organ [8]. Therefore, the aims of this study are to (1) analyze postoperative outcomes and mortality following revision hip and knee arthroplasty in renal transplant recipients (RTRs) compared to non-RTRs and (2) characterize common indications and types of revision procedures among RTRs.

Methods

Data Source

A retrospective database review of all Medicare patient records from 2005 to 2014 searchable by billable codes was performed using the commercially available PearlDiver Patient Records Database (www.pearldiverinc.com; PearlDiver Inc, Colorado Springs, CO). As PearlDiver queried data are de-identified and Health Information Portability and Affordability Act compliant, this study was exempt from institutional review board approval.

Study Population

All Medicare patients who underwent a total or partial revision knee (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]: 00.80, 00.81, 00.82, 00.83, 00.84, 81.55) and hip (ICD-9-CM: 00.70, 00.71, 00.72, 00.73, 81.53) arthroplasties from 2005 to 2014 were identified. Exclusion criteria included age greater than 85 years old, renal retransplantation, other SOT including liver, lung, or heart, and malignancy or metastasis involving the hip or knee joint. The database was queried separately for knee and hip procedures.

Following application of inclusion and exclusion criteria, the resulting cohort of revision joint arthroplasty patients was then separated into the following groups: patients with a history of renal transplantation (ICD-9-CM: V42.0, 556.9; study group) and those without a history of SOT of kidney, liver, lung, or heart (control group). Respective hip and knee control groups were matched to identified RTRs who underwent a revision TKA and THA on the basis of the following demographic factors and comorbidities: age, sex, obesity, tobacco use history, alcohol abuse, peripheral vascular disease, congestive heart failure, chronic obstructive pulmonary disease, hyperlipidemia, and hypertension.

Postoperative Outcome Following Revision Joint Arthroplasty in RTRs

Identified study groups were compared to their respective matched control groups for hospital length of stay (LOS), 90 days hospital readmission, and the diagnosis of major medical complications including stroke, myocardial infarction, acute pulmonary embolism, and acute lower extremity deep vein thrombosis within 90 days of the index procedure. Additionally, we compared both study groups and respective matched control groups for the postoperative diagnosis of infection including periprosthetic joint infection (PJI) and surgical site infection (SSI), septicemia, and mortality within 1 year of revision.

Primary Indications for Revision Joint Arthroplasty in RTRs and Types of Revisions

Identified RTRs who underwent a revision TKA or THA were queried to determine the primary diagnosis associated with the respective revision arthroplasty. Furthermore, both study groups were queried to identify the types of revision knee and hip arthroplasties performed. Specifically, in revision knee arthroplasty patients, the proportion of total, tibial, femoral, or patellar component revisions was determined. The same was performed for revision hip arthroplasty patients to determine the proportion of total, acetabular, acetabular liner and/or femoral head, or femoral component revisions.

Statistical Analysis

A Pearson's chi-squared analysis was used to assess univariate differences in rates of hospital readmission, major medical complications, postoperative infection, septicemia, and mortality between RTRs and their respective matched controls. Additionally, a Welch's *t*-test was used to compare hospital LOS between both groups. Furthermore, linear regression analysis was used to determine the independent effect of renal transplantation among revision TKA and THA patients on LOS, adjusting for demographic factors and comorbidities. Finally, a multivariate logistic regression was used to determine the independent effect of renal transplantation on readmission, major medical complications, postoperative infection, septicemia, and mortality, adjusting for the above-highlighted demographic factors and comorbidities as covariates. R Project for Statistical Computing, available through the database, was used for all statistical analysis. Factors were considered significant at $P < .05$.

Results

Patient Demographics and Comorbidities

A total of 7459 and 13,705 patients who underwent a revision TKA and THA, respectively, were identified. Among them, 359 TKA (4.8%) and 661 THA (4.8%) patients were RTRs. There were no significant differences in demographic factors and comorbidities between both study groups and each respective control groups owing to a matched selection of controls. A summary our study cohorts' comorbidity profiles using the Charlson Comorbidity Index showed that RTRs undergoing revision TKA (7.82 ± 2.81 vs 5.82 ± 2.59; $P < .001$) and THA (6.67 ± 2.45 vs 4.95 ± 2.80; $P < .001$) had an increased Charlson Comorbidity Index compared to nontransplant recipients (Table 1).

Postoperative Outcome Following Revision Joint Arthroplasty in Kidney Transplant Recipients

Revision Knee Arthroplasty

Among revision TKA patients, renal transplant was associated with increased LOS (6.12 ± 7.86 days vs 4.33 ± 4.29 days; $P = .002$) and independently increased hospital LOS by 1.88 days (95% CI, 1.03-2.72; $P < .001$) compared to nontransplant revision TKA patients in an adjusted linear regression model. Furthermore, RTRs had an increased rate of septicemia (14.8% vs 6.0%; OR, 2.52; 95% CI, 1.83-3.46; $P < .001$) and mortality (4.5% vs 1.5%; OR, 2.71; 95% CI, 1.51-4.53; $P < .001$) within 1 year compared to nontransplant revision TKA patients. There was no difference in the incidence of major medical complications including stroke, myocardial infarction, acute pulmonary embolism, and acute lower extremity deep vein thrombosis between RTRs and nontransplant revision TKA

Table 1
Patient Demographics.

Total Numbers	Revision TKA		P Value	Revision THA		P Value
	Renal Transplant 359 (%)	Control 7100 (%)		Renal Transplant 661 (%)	Control 13,044 (%)	
Age (y)			.980			.993
<65	162 (45.1)	3141 (44.2)		443 (67.0)	8647 (66.3)	
65-69	79 (22.0)	1538 (21.7)		89 (13.5)	1758 (13.5)	
70-74	69 (19.2)	1414 (19.9)		75 (11.3)	1513 (11.6)	
75-79	29 (8.1)	629 (8.9)		40 (6.1)	833 (6.4)	
80-84	20 (5.6)	388 (5.5)		14 (2.1)	293 (2.2)	
Male sex	173 (48.2)	3434 (48.4)	.991	333 (50.4)	6586 (50.5)	.987
Obesity (BMI > 30 kg/m^2)	105 (29.2)	2089 (29.4)	.991	101 (15.3)	1946 (14.9)	.843
Tobacco use	113 (31.5)	2249 (31.7)	.983	212 (32.1)	4156 (31.8)	.944
Alcohol abuse	5 (1.4)	98 (1.4)	1.000	21 (3.2)	373 (2.9)	.721
CCI	7.82 ± 2.81	5.82 ± 2.59	<.001	6.67 ± 2.45	4.95 ± 2.80	<.001
Comorbidities						
Diabetes mellitus	218 (60.7)	4334 (61.0)	.948	262 (39.6)	5161 (39.6)	1.000
Peripheral vascular disease	53 (14.8)	1009 (14.2)	.830	49 (7.4)	889 (6.8)	.607
Congestive heart failure	130 (36.2)	2558 (36.0)	.989	149 (22.5)	2884 (22.1)	.831
COPD	132 (36.8)	2601 (36.6)	1.000	197 (29.8)	3872 (29.7)	.983
Hypertension	344 (95.8)	6800 (95.8)	1.000	606 (91.7)	11,951 (91.6)	1.000
Hyperlipidemia	281 (78.3)	5583 (78.6)	.923	438 (66.3)	8608 (66.0)	.919

BMI, body mass index; CCI, Charlson comorbidity index; COPD, chronic obstructive pulmonary disease; TKA, total knee arthroplasty; THA, total hip arthroplasty.

patients within 90 days (11.1% vs 9.0%; OR, 1.21; 95% CI, 0.84-1.69; $P = .272$). Additionally, there was no significant difference in 1-year postoperative infections (24.0% vs 21.5%; OR, 1.09; 95% CI, 0.84-1.40; $P < .494$) and 90-day readmissions (4.5% vs 1.5%; OR, 2.71; 95% CI, 1.51-4.53; $P < .001$) following revision TKA between RTRs and the control group (Table 2).

Revision Hip Arthroplasty

Among revision THA patients, renal transplant was associated with increased 90-day hospital readmission (27.8% vs 23.2%; $P < .007$), septicemia (11.6% vs 6.2%; $P < .001$), and 1-year mortality (6.8% vs 2.3; $P < .001$) compared to nontransplant revision hip patients. As expected, renal transplantation was an independent predictor of 90-day hospital readmission (OR, 1.23; 95% CI, 1.03-1.47; $P = .023$), septicemia (OR, 1.82; 95% CI, 1.41-2.34; $P < .001$), and 1-year mortality (OR, 2.65; 95% CI, 1.88-3.66; $P < .001$) following revision THA. There was no significant difference in hospital LOS between RTRs and nontransplant revision THA patients (5.49 ± 5.51 vs 5.01 ± 5.47 days; $P = .953$). There was also no significant difference in 90-day diagnosis of major medical complications (9.4% vs 8.5%; $P = .456$) and 1-year postoperative infections among revision THA patients (12.2% vs 13.8%; $P = .453$; Table 3).

Indications for Revision Joint Arthroplasty in RTRs and Types of Revisions

Revision Knee Arthroplasty

The most frequent primary diagnoses associated with revision TKA among RTRs were mechanical complications of prosthetic implants although nontransplant revision TKA patients had a higher frequency of other mechanical complications compared to RTRs (39.4% vs 32.3%, $P = .007$). Other mechanical complications of prosthetic implant are defined as mechanical complications not otherwise specified, thus complications not including mechanical loosening, dislocation, periprosthetic fracture and osteolysis, and articular bearing surface wear of prosthetic joint. RTRs had a higher frequency of postoperative infection diagnosis, preoperatively, compared to nontransplant revision TKA patients (31.5% vs

Table 2
Postoperative Outcome Following Revision Joint Arthroplasty in Renal Transplant Recipients.

Postoperative Outcome	Renal Transplant 359 (%)	Matched Control 7100 (%)	P Value	Adjusted OR (95% CI)	P Value
TKA					
Length of stay (d)	6.12 ± 7.86	4.33 ± 4.29	.002	[a]1.88 (1.03-2.72)	<.001
90-d Readmission	87 (24.2)	1417 (20.0)	.057	1.22 (0.94-1.57)	.126
90-d Major medical complications	40 (11.1)	639 (9.0)	.200	1.21 (0.84-1.69)	.272
1-y Infection	86 (24.0)	1526 (21.5)	.298	1.09 (0.84-1.40)	.494
1-y Septicemia	53 (14.8)	436 (6.0)	<.001	2.52 (1.83-3.46)	<.001
1-y Mortality	16 (4.5)	110 (1.5)	<.001	2.71 (1.51-4.53)	<.001
	Renal Transplant 661 (%)	Matched Control 13,044 (%)	P Value	Adjusted OR (95% CI)	P Value
THA					
Length of stay (d)	5.49 ± 5.51	5.01 ± 5.47	.953	—	—
90-d Readmission	184 (27.8)	3025 (23.2)	.007	1.23 (1.03-1.47)	.023
90-d Major medical complications	62 (9.4)	1105 (8.5)	.456	1.04 (0.78-1.35)	.787
1-y Infection	81 (12.2)	1800 (13.8)	.453	0.82 (0.57-1.14)	.262
1-y Septicemia	77 (11.6)	809 (6.2)	<.001	1.82 (1.41-2.34)	<.001
1-y Mortality	45 (6.8)	303 (2.3)	<.001	2.65 (1.88-3.66)	<.001

CI, confidence interval; OR, odds ratio; THA, total hip arthroplasty; TKA, total knee arthroplasty.
[a] Adjust linear regression coefficient (β).

Table 3
Comparison of Common Primary Indications for Revision Joint Arthroplasty Between Renal Transplant Recipients and a Matched Control Cohort.

Primary Diagnosis	Renal Transplant, N (%)	Matched Control, N (%)	*P* Value
TKA			
Other mechanical complications	116 (32.3)	2797 (39.4)	.007
Infection	113 (31.5)	1870 (26.3)	.032
Mechanical loosening	50 (13.9)	1680 (23.7)	<.001
Dislocation of prosthetic joint	33 (9.2)	705 (9.9)	.648
Other acquired deformities	30 (8.4)	574 (8.1)	.854
Broken prosthetic joint implant	16 (4.5)	443 (6.2)	.170
Articular surface wear	15 (4.2)	205 (2.9)	.158
Primary Diagnosis	Renal Transplant, N (%)	Matched Control, N (%)	*P* Value
THA			
Other mechanical complications	180 (27.2)	4783 (36.7)	<.001
Mechanical loosening	178 (26.9)	2909 (22.3)	.005
Dislocation of prosthetic joint	142 (21.5)	3421 (26.2)	.007
Infection	62 (9.4)	1952 (15.0)	<.001
Broken prosthetic joint	42 (6.4)	904 (6.9)	.569
Articular surface wear	46 (7.0)	607 (4.7)	.007
Periprosthetic osteolysis/fracture	49 (7.4)	892 (6.8)	.569

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

26.3%; $P < .032$). However, nontransplant revision TKA patients had higher frequency of preoperative diagnosis of mechanical loosening (23.7% vs 13.9%; $P < .001$) compared to RTRs. There was no significant difference in the preoperative diagnosis of acquired knee deformities (8.4% vs 8.1%, $P = .854$), dislocation of prosthetic joint (9.2% vs 9.9%; $P = .648$), articular surface wear (4.2% vs 2.9%; $P = .158$), and broken prosthetic joint implant (4.5% vs 6.2%; $P = .352$) among the identified common indications for revision joint arthroplasty between RTRs and nontransplant revision TKA patients (Table 3).

Revision Hip Arthroplasty

Among the revision THA group, preoperative diagnoses of mechanical loosening (26.9% vs 22.3%, $P = 0.005$) and articular surface wear (7.0% vs 4.7%; $P = .007$) were higher in RTRs. Nontransplant patients had a higher frequency of preoperative diagnosis of other mechanical complications (36.7% vs 27.2%; $P < .001$), dislocation (26.2% vs 21.5%; $P = .007$), and infection (15.0% vs 9.4%; $P < .001$) compared to RTR. There were no differences in the preoperative diagnoses of broken prosthetic joint and periprosthetic osteolysis or fracture between both groups (Table 3).

Results from the present study demonstrated that all-component revision (52.5%) and revision of tibial component (48.2%) were the most frequent revision procedures performed among RTRs undergoing THA and TKA, respectively. Types of revision knee and hip arthroplasties among RTRs are summarized in Table 4.

Discussion

Following the first renal transplantation over 6 decades ago [9], SOT continues to be the standard of care in most cases of end-stage organ damage with improved graft survival and viability [10]. However, the systemic complications from immunosuppression, graft dysfunction, rejection, and infections, among others, are well established in transplant literature [8]. Revision joint arthroplasty alone has its own sets of inherent complications [11], which can be compounded by an inherently sick transplant population when revision joint arthroplasty is indicated. Hence, the intersection of prior renal transplantation and revision joint arthroplasty creates a challenging clinical scenario that warrants an in-depth investigation on postoperative outcomes. In this study, we found that RTRs undergoing a revision TKA and THA had an increased rate of septicemia and 1-year mortality compared to nontransplant patients undergoing revision arthroplasty. Unexpectedly, there were no significant differences in the rates of major medical complications within 90 days and infection within 1 year following revision arthroplasty between RTRs and matched nontransplant patients. Additionally, all-component revision of hip (52.5%) prosthetic joints and knee revision of tibial component (48.2%) were the most frequent procedures among RTRs.

When considering postoperative complications in the transplant population, infection is often considered first. Immunosuppressive therapies from medications, such as corticosteroids (prednisone), cyclosporine, and tacrolimus, contribute significantly to an increased risk of infection within this population. In all arthroplasty patients, postoperative infections, including SSI and PJI, remain a very common indication for revision [12–14], particularly in complex patient populations such as SOT recipients [7]. Unexpectedly, our result shows that there were no significant differences in the rates of postoperative infections between RTRs and nontransplant patients. While this finding may be perplexing, it could be explained by the adequate matching of the control groups to RTRs based on pertinent demographic factors and known predictors of postoperative infections such tobacco use, diabetes, peripheral vascular disease, and obesity. Recent similar studies on the

Table 4
Revision Arthroplasty in Renal Transplant Recipients.

Knee	ICD-9-CM	N (%)	Hip	ICD-9-CM	N (%)
All components	00.80	160 (44.6)	All components	00.70	347 (52.5)
Tibial component	00.81, 00.84	173 (48.2)	Acetabular component	00.71	115 (17.4)
Femoral component	00.82	74 (20.6)	Acetabular liner and/or femoral head	00.73	111 (16.8)
Patellar component	00.83	30 (8.4)	Femoral component	00.72	103 (15.6)
Unspecified	81.55	39 (10.9)	Unspecified	81.53	72 (10.9)

ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

rate of postoperative SSI and PJI following joint arthroplasty among SOT recipients by Ledford et al [4] and Vergidis et al [15] have been inconclusive. As such, the expected increased rate of infection associated with renal transplant in joint arthroplasty is questionable and merits further research attention, particularly in light of the medical advancements made in transplant medicine and immunosuppressive therapy.

Additionally, the present study's analysis on the rate of septicemia, a highly fatal event among RTRs [16], further accentuates the need for optimal patient monitoring and follow-up among RTRs undergoing revision. We demonstrated that RTRs undergoing a revision joint arthroplasty have more than twice the odds of septicemia following revision TKA and THA within 1 year. Sepsis among RTRs is known to decrease patient survivorship and organ viability [17]. Briggs et al [16] reported that cardiovascular events, malignancy, and infection, specifically septicemia, account for the most common causes of death among RTRs. Indeed, the above-highlighted complications shed light on the expected increased 1-year mortality among RTRs undergoing revision. RTRs have more than 2.5 times the odds of mortality following revision compared to nontransplant recipients. A caveat to our findings is that although an increased risk of complications were found in a multivariate analysis, a number of adverse major medical complications were found not to be significantly different between the groups. Hence, the remaining differences, particularly septicemia and mortality, found in the present study could be explained by the renal transplant status, and less likely joint arthroplasty. For instance, the present study's reported mortality rates of 4.5% and 6.8% among RTRs undergoing revision TKA and THA, respectively, align with the reported 1-year mortality rate for RTRs in general (3%-10%) [16,18,19].

The primary advantage of this study is the large sample size; to our knowledge, this is the largest study evaluating outcome following revision joint among RTRs. Furthermore, a common trend in SOT studies in orthopedic surgery literature involves the pooling of heart, liver, lung, and kidney into a single cohort, perhaps to increase sample size [6,7,20,21]. As the type of transplanted organs cause a varying severity and spectrum of complications on recipients [8], we addressed this limitation by focusing solely on renal transplantation. Lastly, by creating a matched control cohort of nontransplant recipients and controlling for identified pertinent demographic factors and comorbidities as covariates, our study mitigates the confounding effects of preexisting conditions on the independent effects of renal transplantation on revision knee and hip postoperative outcome.

Nonetheless, the present study has a number of limitations. The accuracy of our data is dependent upon the accurate coding of the information in patient medical records. There have been incidences of coding errors reported; particularly, instances of miscoding and noncoding of diagnoses have been previously reported in large databases [22]. Furthermore, preexisting comorbidities are known to be underreported, and the ability of the present study to control for the confounding effects of comorbidities through matching and regression analysis is dependent on the accurate reporting of these comorbidities [23]. Also, the present study falls short of reporting the rate of re-revision primarily due to an inability to confirm laterality within our specific database. This information would be particularly useful to revision joint surgeons who specialize in SOT patients.

Conclusions

Although revision joint arthroplasty and renal transplantation improve health-related quality of life and prolong life, results of the present study indicate that revision joint arthroplasty in patients with a history of renal transplantation is associated with increased morbidity and mortality when compared to nontransplant recipients undergoing the same revision procedures. This patient population may benefit from vigorous medical optimization of chronic conditions preoperatively and close monitoring during the early postoperative period to mitigate postoperative complications.

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