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Original Research

Outcomes Following Surgical Fixation of Distal Radius Fractures in Patients With Chronic Kidney Disease

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A R T I C L E I N F O

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Purpose: Moderate-to-severe chronic kidney disease (CKD, stages III–IV) and end-stage renal disease (ESRD or CKD stage V) are known to be independent risk factors for fragility fracture. Altered bone and mineral metabolism contributes to greater complications and mortality rates in the setting of fractures, although most existing literature is limited to hip fractures. We hypothesized that patients with moderate-to-severe CKD or ESRD would have greater complication rates after surgical treatment of distal radius fractures compared with those without CKD.
Methods: We retrospectively identified all patients at a level 1 trauma center between 2008 and 2018 who had a diagnosis of stage III–IV CKD or ESRD at the time of operative fixation of a distal radius fracture. We recorded demographic data, comorbidities, and surgical complications. Data for readmissions within 90 days and 1-year mortality were collected. A 2:1 sex-matched control group without CKD who underwent distal radius fixation was selected for comparison, with age-adjusted analysis.
Results: A total of 32 patients with CKD (78.1% CKD stage III/IV, 21.9% ESRD) and 62 without CKD were identified. The mean age was 67 ± 12 years in the CKD group and 55 ± 15 years in the control group. The CKD group had a higher Charlson Comorbidity Index (5.7 vs 2.0). Surgical complication rate in the CKD group was 12.5% (12.0% CKD III/IV; 14.3% ESRD). Neither early nor late surgical complication rates were statistically different from those in patients without CKD. Reoperation rate as well as 30- and 90-day readmission rates were similar between groups. Overall, 1-year mortality was greater in the CKD group (9.4% vs 0%).
Conclusions: Surgical complications and readmission rates are similar in patients with and without CKD after distal radius fracture fixation. However, 1-year mortality rate is significantly higher after distal radius fixation in patients with moderate-to-severe CKD or ESRD.
Type of study/level of evidence: Prognostic IIIa.

Distal radius fractures are the most common fracture of the upper extremity.[1,2] Presentation is bimodal, with the highest rates in the under 18-year and over 65-year age demographics. The high incidence of these fractures in patients aged >65 years is attributable to low-energy mechanisms. Distal radius fractures are the second most common fragility fracture after hip fractures.[2]

Patients of the female sex in the perimenopausal and early postmenopausal years are at particular risk for distal radius fracture.[3] This increased risk has been attributed to metabolic changes in bone structure and remodeling.[3] Similar metabolic changes are seen in patients with chronic kidney disease (CKD).[4,5] Specifically, patients with moderate-to-severe CKD (CKD stage III–IV) or end-stage renal disease (ESRD or CKD stage V) suffer from metabolic changes in vitamin D metabolites that lead to reduced bone quality and strength with an increased risk for fracture.[4]

Operative management of fractures in patients with CKD stage III–IV or ESRD is controversial. Available literature is limited to hip fractures and concludes that these patients are at increased risk of

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postoperative complications, including infection, cardiovascular events, pulmonary embolism, and death.[6,7] In this cohort of patients, similar findings have been reported for elective surgeries.[8,9] However, there is a lack of evidence describing complications following surgical fixation of distal radius fractures.

The optimal treatment algorithm for distal radius fractures is heavily debated.[10] Prior studies have found better functional outcomes with operative treatment, but higher rates of surgical complications in elderly patients (aged >65 years).[10,11] These studies did not describe the role that kidney disease should play in the decision-making process. There is very limited evidence that patients with distal radius fractures and ESRD can be treated operatively or nonsurgically with no difference in function.[12] However, there are no studies that describe the complications of surgical fixation. We hypothesize that these patients will have higher rates of complications than those without kidney disease.

Materials and Methods

We conducted an institutional review board−approved, retrospective cohort study on all patients with CKD stages III−IV and/or ESRD who sustained a distal radius fracture treated with surgical fixation between January 1, 2008, and December 31, 2018. All patients were treated at an academic level 1 trauma center by surgeons with subspecialty training in either hand/upper extremity or trauma. All surgeons utilized similar postoperative rehabilitation protocols. We included all fractures that were classified as a distal radius fracture, including intra-articular (AO type C1-3), partial articular (AO type B3), and extra-articular (AO type A2-3) fractures. Methods of fixation included open reduction internal fixation (ORIF) with a volar locking plate, closed reduction and percutaneous pinning (CRPP), and external fixation. Any fracture that was treated nonsurgically was excluded. We included patients who had a documented CKD diagnosis prior to the time of injury. Patients with CKD stage III (glomerular filtration rate, 20−59 mL/min), stage IV (15−29 mL/min), and stage V (glomerular filtration rate, <15 mL/min) were included. Patients with stage V CKD on dialysis were included and classified as ESRD. Those with acute kidney injury or a history of renal transplant were excluded. We defined CKD stage III and IV as moderate-severe CKD.

We then included an age- and sex- matched control group. All patients who sustained a distal radius fracture that was treated operatively in the same time period were included. Those with a CKD diagnosis of any stage or ESRD were excluded. Those with acute kidney injury or a history of renal transplant were excluded. We then performed 2:1 (control:CKD) matching. Cohorts were matched for both age (±5 years) and sex.

For both the control and CKD groups, patient demographics were collected. Pertinent medical history, including smoking status (never, former, or current), Charlson Comorbidity Index, and diabetes (and associated hemoglobin A1c), was also recorded. Kidney disease markers were collected, including preoperative CKD stage, creatinine, glomerular filtration rate, dialysis dependence, and presence of an arteriovenous (AV) fistula. Fracture characteristics recorded included date of injury, fracture location, and closed versus open injury. Surgery date, fixation technique, tourniquet use, and any intraoperative complications were collected. All major complications, both medical and surgical, were recorded for up to 1 year after surgery. Major surgical complications were defined as those that resulted in aborted surgery, hardware failure, loss of reduction, deep infection, malunion, nonunion, and postoperative wound complication. Minor surgical complications, not requiring intervention, were excluded, such as expected postoperative stiffness, weakness, or pain. Major medical complications that resulted in an emergency department visit or readmission were included.

Table 1
Demographic Characteristics Comparing CKD and Non-CKD Groups

Demographic	CKD (n = 32)	Non-CKD (n = 62)	Significance
Age (y), mean	67	55	
BMI, mean	31.0	26.7	*
Charlson Comorbidity Index, mean	5.7	2.0	†
Smoking status, n (%)			
Never	11 (34.4)	33 (53.2)	†
Former	18 (56.3)	10 (16.1)	†
Current	3 (9.4)	18 (29)	†
Diabetes, n (%)	14 (43.7)	3 (4.8)	†

BMI, body mass index.
* $P < .01$.
† $P < .001$.

All complications were subclassified as early (less than 90 days after surgery) or late (more than 90 days but less than 1 year after surgery) complications. We recorded the need for any repeat surgery and any mortality within the first year after surgery.

Statistical analysis was conducted in a retrospective cohort fashion. Groups were matched for age and sex. Categorical variables were compared using chi-square analysis. Continuous variables were compared with a paired t test. All statistical analyses were controlled for age. Alpha was set at $P \leq .05$.

Results

Patient demographics included a mean age of 59.4 ± 14.9 years, with the majority of subjects being female (72.3% female; 27.7% male). Average body mass index was significantly higher in the CKD cohort ($P < .01$). The CKD cohort was noted to have a higher number of former smokers, whereas the non-CKD cohort had more current and never smokers ($P < .001$). The CKD cohort had a significantly higher presence of diabetes diagnosis (43.7% vs 4.8%; $P < .001$). Average Charlson Comorbidity Index score was 5.7 in the CKD cohort and 2.0 in the non-CKD cohort ($P < .001$) (Table 1). In the CKD stage III/IV group, 87.5% of patients were treated with ORIF with a volar locking plate. The remaining 12.5% of patients were treated with CRPP. In the CKD stage V group, 71.4% of patients were treated with ORIF with a volar locking plate, 14.2% of patients were treated with CRPP, and 14.2% of patients were treated with external fixation. In the non-CKD group, 95.9% of patients were treated with ORIF with a volar locking plate and 4.1% were treated with CRPP.

Early surgical complications (<90 days) were observed in a total of six patients, and late surgical complications (>90 days, but within 1 year) were observed in nine patients. Surgical complication rate in the CKD group was 12.5% (12.0% CKD III and IV, 14.3% CKD V). The observed surgical complications included aborted surgery secondary to poor skin quality, hardware failure related to loosening, loss of reduction, loss of reduction secondary to fall necessitating revision, and a postoperative pressure wound. There were no observed differences in complication rates between CKD and non-CKD groups ($P = .14$). Loss of reduction was the most common early surgical complication (Table 2).

Reoperation rate within 1 year after surgery was significantly higher in the non-CKD cohort (19.4% vs 3.2%; $P = .035$) when including planned second-stage surgeries (removal of dorsal bridge plate or external fixator). However, reoperation rates were no different between the two groups when excluding planned second-stage procedures (3.2%; $P = .96$) (Table 3). Unplanned reoperations were performed for revision fixation (n = 2), irrigation and debridement with hardware removal (n = 1), and palmaris longus to extensor pollicis longus tendon transfer (n = 1).

Table 2
Incidence of Complications Noted Between CKD and Non-CKD Groups

Complication	CKD	Non-CKD
	Incidence (n = 32)	Incidence (n = 62)
Early surgical complications		
Loss of reduction	2	2
Pressure injury	1	0
Wound dehiscence	0	1
CRPS	0	1
Late surgical complications		
Malunion	1	2
Painful hardware	0	4
EPL rupture	0	1
Delayed deep infection	0	1
Unplanned reoperations		
Revision fixation	1	1
Debridement, hardware removal	0	1
Palmaris longus to EPL tendon transfer	0	1

CRPS, chronic regional pain syndrome; EPL, extensor pollicis longus.

Table 3
Complication Rates Observed Between CKD and Non-CKD Groups

Outcomes	CKD	Non-CKD	*P* Value
Complication rate	12.5%	17.2%	.14
Reoperation rate at 1 y*	3.2%	3.2%	.96
30-d readmission rate	6.3%	6.5%	.97
90-d readmission rate	6.3%	3.2%	.49
1-y mortality	9.4%	0%	.02†

* After excluding planned second-stage procedures.
† $P < .05$ accepted as significant.

There was no significant difference in index hospitalization complications, 30-day readmission rates, or 90-day readmission rates between CKD and non-CKD groups ($P = .357$; $P = .97$; $P = .491$). Among the medical complications, the only statistically significant difference observed between the two cohorts was a higher 1-year mortality rate in the CKD group (9%) compared with non-CKD group ($P = .016$). The observed medical complications included acute encephalopathy, delirium, implantable cardioverter defibrillator activation secondary to arrhythmia, lumbar radiculopathy, and acute respiratory failure secondary to pulmonary edema. Among the CKD stage V group (n = 7), all had an AV fistula in the upper extremity with five ipsilateral to the fracture. A tourniquet was utilized in four of these patients without complications. There were no reported dialysis access complications after surgery.

Discussion

Distal radius fractures are the most common fracture of the upper extremity.[1,2] They also represent the second most common fragility fracture.[3] As the US population continues to age, these low-energy fragility fractures are a growing concern. An abundance of research has been conducted focusing on changes in bone structure and remodeling in the aging population.[3] Nickolas et al[4] demonstrated that patients with CKD have similarly altered bone metabolism. Alterations in vitamin D quantity and activation lead to reduced bone quality and strength with an increased risk for fracture. There have been several studies elucidating the higher risk of postoperative complications in patients with CKD after hip fractures. These include infection, cardiovascular events, pulmonary embolism, and death. However, these studies all examined outcomes after lower extremity fractures, well known to have increased complications and a more difficult recovery overall than upper extremity fractures.[6,7]

Additionally, the literature is divided on optimal treatment of distal radius fractures in those aged >65 years or those with a functionally higher age.[10,11] There continues to be heavy debate on the best treatment strategy, and there is a paucity of literature on patients with CKD. Chang et al[12] looked at functional outcomes after nonsurgical versus operative treatment of distal radius fractures in patients with ESRD. They found that there was no difference in functional outcomes between the two groups: operative versus nonsurgical.[12] However, there are no studies looking at outcomes in those with moderate-severe CKD (non-ESRD) or specifically looking at surgical complications in these patients.

In our cohort of patients, there were no statistically significant differences between surgical complication rates in the CKD and non-CKD cohorts. However, we acknowledge that this is a difficult outcome to track, given the inherently small number of surgical complications after distal radius fractures overall. Our study focused on major surgical complications and did not include more prevalent adverse outcomes such as stiffness, weakness, and pain as the retrospective nature of our study would require introduction of subjective biases, and no objective measures such as patient-reported outcomes or grip strength were available to review.

Method of fixation among the groups was similar. Open reduction internal fixation with a volar locking plate was the most common method employed in patients with and without CKD. Although not investigated in this study, the use of modeling to see how the fixation method might influence complication rate within the individual CKD and non-CKD groups would be useful in the future.

Similarly, there was an equivalent reoperation rate among both cohorts. Both reoperation rate and surgical complications are difficult to track in small cohorts. However, both of these findings were surprising as prior literature has described substantially higher complications after fractures in patients with CKD. Prior literature has focused on outcomes after lower extremity fractures. Our patient population indicates that the severe adverse outcomes may be mitigated in distal radius fractures.

Importantly, the patients with moderate-severe CKD did have a significantly higher 1-year mortality rate of 10%. This rate is consistent with current evidence in the nephrology literature of 10% to 20% 1-year mortality in moderate, non−dialysis-dependent patients.[13] Interestingly, 30- and 90-day readmission rates were no different in both groups and are within reported ranges of readmission rates following operative distal radius fractures.[14−16] Patients with CKD are shown to have higher readmission rates and mortality following lower extremity fracture care compared with patients without kidney disease.[17] The additional impact of kidney disease on frailty scores in patients with CKD could be a contributing factor to the observed higher mortality rate and should perhaps be taken into account when managing these injuries.[18] Other comorbidities such as insulin-dependent diabetes, American Society of Anesthesiologist class, and frailty have been implicated as predictors for readmission following distal radius fracture fixation, and further work may help elucidate how kidney disease might prognosticate readmissions and mortality in these patients.[16,19]

We also report outcomes in those with an AV fistula. Five patients had an AV fistula ipsilateral to the distal radius fracture. Of these, a standard tourniquet inflated at 250 mm Hg proximal to the antecubital fossa was used in four of these patients. Fistula location varied, including ipsilateral brachiocephalic, basilic, radiocephalic, and antecubital sites. All patients were treated successfully without any reported dialysis complications. Although this is a small population, this suggests that a tourniquet can be used safely in these patients. Additionally, operating on these patients has the added benefit of improving access to their existing AV fistula through immobilization with a less invasive technique after surgery.

Our study has several limitations. This narrowly focused study has a small patient population. Although our center has a large number of patients with CKD, the vast majority of these patients who sustain a distal radius fracture are treated nonsurgically. The retrospective nature of our study introduces a selection bias related decision making of operative versus nonsurgical treatment that we cannot control for. Future work with a dedicated nonsurgical group would help to mitigate this and better establish clear indications for and against surgery. Although we did perform 2:1 gender cohort matching with age-adjusted analysis, the inherently low complication rate after distal radius fixation limits the power of the study. Most distal radius fractures are treated on an outpatient basis. This limited some of the data available for review and resulted in several patients being excluded from the control patient population for missing data variables. All patients with CKD stage 3 through 5 were included, and none had missing data. Future investigation is needed with larger patient numbers to further investigate differences in patients with CKD as well as ways to minimize their surgical and medical risk.

As our population continues to age and comorbidities are increasingly common, it is important that we continue to evaluate each patient on an individual basis. This study suggests no significant differences in surgical complications and readmission rates between patients with CKD and those without CKD but an observed higher 1-year mortality rate in patients with CKD. These results may be valuable when counseling patients and informing decision making in surgical treatment plans for these injuries in this population.

Conflicts of Interest

No benefits in any form have been received or will be received related directly to this article.

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