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Original Research

Outcomes Following Surgical Fixation of Upper Extremity Fractures in Patients with Chronic Kidney Disease

Patricia K. Wellborn, MD, * Alexander D. Jeffs, MD, * Andrew D. Allen, MD, * Nathaniel T. Koutlas, MD, * Reid W. Draeger, MD, * J. Megan M. Patterson, MD, * Andrew T. Chen, MD *

* The Department of Orthopaedics, The University of North Carolina, Chapel Hill, NC

A R T I C L E I N F O

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Purpose: Moderate to severe (stage III–IV) chronic kidney disease (CKD) and end stage renal disease (ESRD) have been shown to be independent risk factors for sustaining a fragility fracture. High rates of complications and mortality are associated with fracture fixation in patients with CKD, but existing literature is limited. It is unknown how CKD stage III–IV or ESRD affects outcomes in upper-extremity fractures. We hypothesize that patients with CKD stage III–IV or ESRD will have high complication rates after surgical fixation of upper extremity fractures.
Methods: We identified all patients between 2008 and 2018 who underwent operative fixation of an upper extremity fracture proximal to the distal radius with a diagnosis of CKD stage III–IV or ESRD at the time of injury. Those with an acute kidney injury at the time of injury or a history of a kidney transplant were excluded. Demographics, medical complications, and surgical complications were collected retrospectively. Data on readmissions within 90 days and mortality within 1 year were also collected.
Results: Thirty-five patients were identified. Three patients had ESRD. Fractures included two clavicle, twelve proximal humerus, one humeral shaft, ten distal humerus, five olecranon, two ulnar shaft, one radial shaft, and two both-bone forearm fractures. In total, 91.4% of fractures were closed injuries. Surgical complications occurred in 40% of patients. The reoperation rate was 11.4%, and all cases of reoperation involved hardware removal. The all-cause 90-day readmission rate was 34.3%. The 1-year mortality rate was 8.6%.
Conclusions: Surgical complications occurred in 40% of patients with CKD stage III–IV or ESRD who underwent fixation for an upper extremity fracture. It is important to counsel these patients regarding their high risk for complications. Further research is needed to investigate and identify how to mitigate risk.
Type of study/level of evidence: Prognostic IV.

Fractures of the upper extremity from the proximal clavicle to the distal phalanges are common and represent an annual incidence of 67.6 fractures per 10,000 persons.[1] Classically, the presentation of these fractures is bimodal, and these fractures can be easily grouped into high-energy fractures in younger patients (<18 years) and low-energy fractures in older patients (>65 years).[1] These low-energy fragility fractures are of growing concern in an aging population. Hip fractures represent the most common nonvertebral fragility fracture; however, this is followed closely by a high incidence of upper extremity fractures.[2]

The risk factors for fragility fractures are well established for hip fractures. End stage renal disease (ESRD) or moderate to severe (stage III–IV) chronic kidney disease (CKD) have both been shown to be independent risk factors for sustaining a fragility fracture of the hip.[3,4] The high incidence of fractures in this subset of patients is attributed to the metabolic effects of renal osteodystrophy and the increased prevalence of risk factors for falls.[4] There is less known about upper extremity fractures in these patients.

In general, fractures necessitating surgical fixation are of concern in patients with ESRD or CKD stage III–IV. Prior studies

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Corresponding author: Patricia K. Wellborn, MD, The University of North Carolina, 130 Mason Farm Road, Chapel Hill, NC 27514.

E-mail address: Patricia.wellborn@unchealth.unc.edu (P.K. Wellborn).

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have reported higher rates of complications following surgical fixation of hip fractures in these patients.[5,6] Patients were at increased risk for postoperative infection, cardiovascular event, and mortality.[5,6] There remains a paucity of research investigating the outcomes following surgical fixation of upper extremity fractures in patients with CKD stage III–IV or ESRD. Specifically, there are no studies that describe the complications of surgical fixation of upper extremity fractures proximal to the distal radius and ulna. We hypothesize that these patients will have high rates of postoperative complications.

Materials and Methods

After obtaining institutional review board approval, we retrospectively collected all cases of patients with CKD stage III–IV or ESRD who sustained an operative upper extremity fracture proximal to the distal radius and ulna from 2008 to 2018. All patients were treated by subspecialty trained surgeons. Fractures of the clavicle/scapula proximally through the radial/ulnar shaft distally were included. All fractures of the distal radius, distal ulna, carpus, or hand were excluded. Any fracture that was treated nonsurgically was excluded. All patients had a documented diagnosis of CKD stage III–IV or ESRD prior to their injury. Specifically, patients with CKD stage III (glomerular filtration rate (GFR) 30–59 mL/min), stage IV (GFR 15–29 mL/min), and ESRD (GFR <15 mL/min) were included. Patients on dialysis were included. CKD stage was defined based on the National Kidney Centers classification. Those with acute kidney injury at the time of injury or a history of a renal transplant were excluded. We defined CKD stage III and IV as moderate to severe CKD and stage V as ESRD dialysis-dependent CKD.

Patient demographics, including age and gender, were collected. Pertinent medical histories, including smoking status, Charlson Comorbidity Index, and a diagnosis of diabetes mellitus were also recorded. Well-established markers of kidney disease were collected, including preoperative CKD stage, creatinine, GFR, dialysis dependence, and the presence of an arteriovenous fistula. Fracture characteristics recorded included date of injury, fracture location, and closed versus open injury. Operative characteristics collected included surgery date, method of fixation, tourniquet use, and any intraoperative complications. All complications, both medical and surgical, were recorded. Complications were subdivided into surgical complications (directly related to surgery or fracture-related postoperative care) that occurred up to 1 year after surgery or medical complications that occurred during the index hospitalization up to 90 days after surgery. Additionally, all complications were subclassified into early (less than 90 days after surgery) or late (greater than 90 days after surgery) complications. Information on any repeat surgical procedure and/or mortality within the first year after surgery was collected. All data were analyzed individually and by CKD stage.

Results

Thirty-five patients, including 10 males and 25 females, were identified. The mean age was 69 years old. There were 26 patients with CKD stage III, six with CKD stage IV, and three with ESRD (Table 1). Of the three dialysis-dependent patients, only one patient had an arteriovenous fistula present, and this was ipsilateral to the fracture. Fractures included two clavicle, twelve proximal humerus, one humeral shaft, ten distal humerus, five olecranon, two ulnar shaft, one radial shaft, and two both-bone forearm fractures (Table 2). All but three fractures were closed injuries (91.4%).

Of the 35 patients, 24 (68.5%) sustained a medical or surgical complication between the index surgery and 1 year after surgery.

Table 1
Demographics of Patients with Moderate to Severe CKD (III–IV) and ESRD (V)

	CKD III–IV (n = 32)	ESRD (n = 3)	Total (n = 35)
	Average (STD)	Average (STD)	Average (STD)
Age, y*	70.2 (12.6)	54.3 (13.2)	68.8 (13.2)
BMI	27.6 (7.1)	25.6 (1.5)	27.4 (6.8)
CCI	5.3 (2.7)	6 (2)	5.4 (2.6)
	n (%)	n (%)	n (%)
Gender*			
Male	7 (21.9)	3 (100.0)	10 (28.6)
Female	25 (78.1)	0 (0.0)	25 (71.4)
Tobacco use			
Never	13 (40.6)	2 (66.7)	15 (42.9)
Former	15 (46.9)	1 (33.3)	16 (45.7)
Current	4 (12.5)	0 (0.0)	4 (11.4)
DM			
None	15 (46.9)	1 (33.3)	16 (45.7)
T1DM	2 (6.3)	0 (0.0)	2 (5.7)
T2DM-NID	5 (15.6)	1 (33.3)	5 (14.3)
T2DM-ID	9 (28.1)	1 (33.3)	10 (28.6)

BMI, body mass index; CCI: Charlson comorbidity index; DM, diabetes mellitus; T1DM, type 1 diabetes mellitus; T2DM-ID, insulin-dependent type 2 diabetes mellitus; T2DM-NID, noninsulin-dependent type 2 diabetes mellitus.
* $P < .05$

Table 2
Distribution of Fracture Types Among Patients with Moderate to Severe CKD (III–IV) and ESRD (V)

Fracture Location	CKD Stage III–IV (n = 32)	ESRD (n = 3)
Clavicle	1	1
Proximal humerus	11	1
Humeral shaft	1	0
Distal humerus	9	1
Olecranon	5	0
Ulnar shaft	2	0
Radial shaft	1	0
Both-bone forearm	2	0

The complication percentage was similar between the CKD III–IV group (68.8%) and ESRD group (66.7%) (Table 3).

Complications were subdivided into either medical or surgical complications (Table 3). Surgical complications occurred in 14 patients (40% of cohort) during either the index surgery/hospitalization or 1-year postoperative course. These complications included hardware/fixation failure, nonunion, deep infection/osteomyelitis, superficial infection, neuritis/nerve palsy, periprosthetic fracture, avascular necrosis, and wound dehiscence. All medical and surgical complications, including early and late complications, are summarized in Table 4. Four patients underwent revision surgery (11.4%). All cases of revision surgery necessitated hardware removal, including two related to hardware failure and two related to wound dehiscence/infection.

The all-cause 90-day readmission rate was 34.3%. The readmission rate was further subdivided into a 8.6% readmission rate for fracture-related complications and a 25.7% readmission rate for medical-related complication. Medical complications occurred during index surgery/hospitalization in 25.7% of patients. One-year mortality occurred in three patients (8.6%). Causes of death included septic shock because of lower extremity cellulitis, respiratory failure, and seizure leading to cardiopulmonary collapse.

Discussion

Although the distal radius fracture is the most common fragility fracture of the upper extremity, Baron et al[7] found that, at older ages,

Table 3
All Medical and Surgical Complications from the Index Surgery and Hospitalization up to 1 Year After Surgery

	CKD III–IV	ESRD	Total
Early Surgical Complications*			
Periprosthetic fracture	1	0	1
Poor bone quality	1	0	1
Median nerve palsy	1	0	1
Superficial infection	0	1	1
Deep infection	1	0	1
Wound dehiscence	2	0	2
Peripheral neuritis	3	0	3
Hardware failure	1	0	1
Total	10	1	11
Early Medical Complications*			
Urinary retention	1	0	1
Urinary catheter replacement	1	0	1
Pleural effusion	1	0	1
Urinary tract infection	4	0	4
Atrial fibrillation	1	0	1
Hypoxia	2	0	2
Hypotension	2	0	2
Stasis dermatitis with cellulitis	2	0	2
Postoperative anemia (Hgb < 6)	1	0	1
Diverticulitis	1	0	1
Viral Pharyngitis	1	0	1
Herpangina	1	0	1
NSTEMI	1	0	1
Seizure	3	0	3
Hyperkalemia	1	0	1
Supratherapeutic INR	1	0	1
Nausea/vomiting	0	1	1
Total	24	1	25
Late Surgical Complications†			
Avascular necrosis	2	0	2
Painful hardware	2	0	2
Hardware failure	1	0	1
Nonunion	2	0	2
Total	7	0	7
Total Complications	41	2	43

Hgb, hemoglobin; INR, international normalized ratio; NSTEMI, non-ST-elevation myocardial infarction.
* Early: < 90 days after surgery
† Late: > 90 days after surgery

Table 4
Complication Rates for Moderate to Severe CKD (III–IV) and ESRD (V), Including 90-Day Readmission, Surgical Complications from the Index Surgery to 1 Year After Surgery, Medical Complications up to 90 Days After Surgery and 1-Year All-Cause Mortality

Complication	CKD Stage III–IV		ESRD		All Patients	
	n	%	n	%	n	%
Readmission (total)	10	31.3	2	66.7	12	34.3
Readmission (surgical)	2	6.3	1	33.3	3	8.6
Readmission (medical)	8	25	1	33.3	9	25.7
Surgical complications	13	40.6	1	33	14	40
Medical complications	9	28.1	0	0	9	25.7
Either complications	22	68.8	2	66.7	24	68.6
One-year mortality	3	9.4	0	0	3	8.6

other fractures of the upper extremity occurred more frequently. By age 85–89 years, they found that fractures of the proximal humerus occurred almost as often.[7] The limited research that exists for fragility fractures of the upper extremity is focused heavily on the distal radius, and there is a deficit of literature related to the myriad of other upper extremity fractures. By eliminating the distal radius from our fracture cohort, we sought to highlight the importance of understanding other upper extremity fractures without a disproportionate influence from distal radius fractures.

Fragility fractures are classically associated with elderly patients given the changes that occur in bone mass and microarchitecture related to osteoporosis. Similar effects on bone quality have been noted in kidney disease patients. The pathophysiology of kidney disease is such that hormone and electrolyte imbalances lead to abnormalities in bone termed renal osteodystrophy. There is a high prevalence of CKD stage III–IV and ESRD in elderly patients. Patients with kidney disease are also plagued by risk factors for falls. This risk combined with poor bone quality creates a high-risk environment for fractures.

The higher prevalence of fractures in this population is concerning when considering the role of surgical fixation in management. Overall, 68.5% of the patients in our case series sustained a medical or surgical complication between their index surgery and 1 year after surgery. Interestingly, there was no difference in the overall complication rate between the CKD stage III–IV group and the ESRD group. Therefore, these results suggest that hemodialysis was not an independent risk factor for overall complications among our patients. This varies slightly from what has been reported previously in patients with kidney disease and hip fractures. Lin et al[8] found significantly higher rates of complications and mortality postoperatively in patients on hemodialysis compared to those not on hemodialysis. In addition, Kaneko et al[6] looked at all long-bone fractures in patients on hemodialysis and found higher rates of major cardiovascular events, infection, and mortality. Their analysis included upper extremity fractures but was heavily weighted by hip fractures. Unfortunately, the size of our ESRD group was too small for adequate power in the comparison. Future prospective comparisons in kidney disease patients with upper extremity fractures on and not on hemodialysis will be needed to better support or refute this difference.

Furthermore, when the complications in our patients were subdivided into medical or surgical complications (Tables 3 and 4), we found that surgical complications occurred in 40% of patients between the index surgery and 1 year after surgery. It has been well established that medical complications occur frequently in patients with kidney disease. We found this to be true in our group with an overall 34% 90-day readmission rate, of which 75% occurred secondary to a medical complication. The high risk of a surgical complication within 1 year from surgery and the high risk of a medical complication necessitating readmission within 90 days after surgery should be strongly considered by patients and providers when deciding between nonsurgical or operative management of upper-extremity fractures.

The surgical complications we found ranged in severity. Unfortunately, 11.43% resulted in the morbidity of a revision surgery necessitating hardware removal. At 1 year, we saw a mortality rate of 9%. These high rates of surgical complications and severe medical outcomes suggest that nonsurgical management should be given strong consideration whenever possible. However, nonsurgical management itself is not without risk and can result in skin complications from immobilization, malunion, nonunion, and further functional debility. Each patient and fracture should be evaluated on an individual basis, and a thorough risk-benefit discussion should occur between the patient and provider.

Our case series was not without limitations. Our study was a relatively small case series that lacked a comparison group. The difficulty in collecting an adequate group for comparison stemmed from our study design. We relied on GFR and creatinine at the time of injury to assign patients to their CKD groups. Unfortunately, patients without risk factors or known CKD rarely have these data collected at the time of injury. This discrepancy made collecting a "healthy" comparison group retrospectively impossible. Future studies with cohorts collected prospectively could successfully mitigate this limitation and include nonsurgically treated patients as well. Overall, larger cohorts of prospectively collected patients are needed to better understand the risk of kidney disease in the management of upper extremity fractures. Specifically, a better understanding of how to mitigate these risks is crucial in the scenario that surgical intervention is unavoidable.

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