Management of Femoral and Tibial Shaft Fractures in Patients With Chronic Spinal Cord Injury

Andres Fidel Moreno-Diaz, MD,[a] Cade A. Morris, MD,[a] Sarah Obudzinski, MD,[b] Patrick R. Taylor, MD,[b] Marissa Pazik, MS,[c] Jaquelyn Kakalecik, MD,[c] Michael Talerico, MD,[c] Laura Lins, MD,[d] Gabrielle Kuhn, MD,[d] Paul Whiting, MD,[d] Andrew Chen, MD,[b] Andrew Farley Tyler, MD,[e] Phillip M. Mitchell, MD,[a] and William T. Obremskey, MD[a] on behalf of Southeastern Fracture Consortium

OBJECTIVES: To compare outcomes and complications between nonoperative and operative management of femur and tibia fractures in patients with paraplegia or quadriplegia from chronic spinal cord injury (SCI).

METHODS:

Design: Retrospective cohort study.

Setting: Three Level-1 Trauma centers.

Patient Selection Criteria: All adult patients with paraplegia or quadriplegia due to a chronic SCI with operative or nonoperative treatment of a femoral or tibial shaft fracture from January 1, 2009 through December 31, 2019 were included.

Outcome Measures and Comparisons: Outcomes collected included range of motion, pain, return to baseline activity, extent of malunion, and treatment complications (infection, pressure ulcers, nonunion, deep vein thrombosis/pulmonary emobolus, stroke, amputation, death). Comparison between operative and nonoperative treatment were made for each outcome.

RESULTS: Fifty-nine patients with acute lower extremity fracture in the setting of chronic SCI fulfilled inclusion criteria with a median age of 46 years in the operative group and 47 years in the nonoperative group. Twelve patients (70.6%) in the nonoperative group were male with 32 (76.2%) male patients in the operative group. Forty-six patients (78%) presented as low energy trauma. Differences were seen between operative and nonoperative management for pressure ulcers (19% vs. 52.9%, $P = 0.009$) and mean Visual Analog Scale pain score at first follow-up (1.19 vs. 3.3, $P = 0.03$). No difference was seen for rates of infection, nonunion, deep vein thrombosis/pulmonary emobolus, stroke, amputation, death, return to baseline activity, and range of motion.

CONCLUSIONS: Tibial and femoral shaft fractures commonly resulted from low energy mechanisms in patients with chronic SCI. Operative treatment seemed to decrease morbidity in these patients via lowered rates of pressure ulcers and decreased pain compared with nonoperative management.

KEY WORDS: trauma, lower extremity fracture, spinal cord injury, quadriplegia, paraplegia

LEVEL OF EVIDENCE: Therapeutic, Level III. See Instructions for Authors for a complete description of levels of evidence.

(*J Orthop Trauma* 2024;38:592–595)

INTRODUCTION

Approximately 302,000 people in the United States are living with some form of spinal cord injury (SCI), with about 18,000 new SCI cases each year.[1] Advances in the treatment and care of these individuals have increased survival of the initial injury; however, many face complications and comorbidities postinjury. Osteoporosis is commonly seen in this patient population with proximal femoral bone mineral density (BMD) reported to reduce as much as 3.0% per month within the first year and can decrease up to 50%–70% in the first 7 years, most commonly in the lower extremities.[2,3] A combination of comorbidities including decreased BMD and neurologic injury—muscle weakness, decreased protective sensation, and inhibited reflexes—has resulted in a fracture rate of roughly 2% in patients with SCI, twice that of non-injured persons, with lower extremity injury predominating.[4]

Treatment options for these fractures include both nonoperative and operative modalities, with ongoing debate surrounding which approach is superior. Common nonoperative care involves immobilization with bracing or splinting accompanied by routine radiographic examination to ensure union and evaluate fracture displacement or malalignment. Operative options include intramedullary nailing and open reduction internal fixation, generally using plates and screws. Although nonoperative measures protect from the risks of anesthesia or surgery, malunion is a common problem and

Accepted for publication August 7, 2024.
From the [a]Department of Orthopaedics and Rehabilitation, Vanderbilt University Medical Center, Nashville, TN; [b]UNC Orthopaedics, Chapel Hill, NC; [c]University Florida Health Orthopaedics and Sports Medicine Institute, Gainesville, FL; [d]Department of Orthopedics and Rehabilitation, University of Wisconsin, Madison, WI; and [e]Orthopedic Specialists of Texas Webster, Webster, TX.
The authors report no conflict of interest.
Presented as a poster at the Annual Meeting of the OTA, October 12–15, 2022, Tampa, FL.
Reprints: William T. Obremskey, MD, Vanderbilt University Medical Center, 1215 21st Avenue South, #4200 Nashville, TN 37232 (e-mail: william.obremskey@vumc.org).

DOI: 10.1097/BOT.0000000000002902

issues such as pressure ulcers can lead to infection and sepsis.[5] However, operative management carries with it the risk of surgical site infection, along with risks associated with anesthesia.

Current literature gives unclear guidance as to the best treatment modality. Mortality has been shown to have no difference between operative and nonoperative treatment groups,[6] whereas a small case series reported more complications in nonoperatively treated patients with SCI, including malunion, nonunion, and venous thromboembolism.[7] This multicenter retrospective cohort study aims to compare outcome and complication rates for operative and nonoperative treatment of lower extremity femoral and tibial shaft fractures in patients with paraplegia or quadriplegia from chronic SCI.

METHODS

After institutional review board approval, the authors retrospectively reviewed cases of femoral or tibial shaft fractures treated operatively or nonoperatively in patients with chronic SCI over a 10-year period at 3 Level-1 Trauma centers. Inclusion criteria were as follows: age >18 years at time of fracture, timing of fracture between January 1, 2009 and December 31, 2019, CPT codes 27506, 27507, 27758, 27759 (operative) or 27500, 27502, 27750, 27752 (nonoperative) in patients with paraplegia or quadriplegia (ICD9 codes 344.0, 344.1 and ICD10 code G82) due to chronic (>6 months before lower extremity fracture) SCI. Patients were excluded if they had less than 3 months of follow-up, were pregnant at time of fracture and/or treatment, and if paraplegia or quadriplegia were from a cause other than SCI.

After medical record review, patients were categorized based on operative or nonoperative management of their fracture. Demographic data, including medical comorbidities, were collected. American SCI Association Impairment Scale score was calculated based on baseline before fracture and recorded. Injury characteristics were gathered, including mechanism of injury, fracture location, and type of implant used if treated operatively. The authors collected complications, including those resulting from closed management (ie, pressure sores), infection, reoperation, nonunion, and malunion. Medical complications occurring during the course of treatment were also recorded. Clinical outcomes {range of motion [ROM] (knee ROM—not recorded, limited or normal—same as other side), pain (Visual Analog Scale [VAS], return to baseline activity [yes/no])} and radiographic outcomes [malunion (>20 degrees)] were collected. Only patients with at least 3 months of follow-up were included for statistical analysis.

Statistical Analysis

Demographic data were summarized using descriptive statistics. Student *t*-test was used to compare continuous variables between groups. χ^2 test and Fisher exact test were used for comparing categorical variables. Statistical significance for all tests was set a priori at alpha < 0.05. All statistical calculations were performed using STATA 16 software (StataCorp. 2019 *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC; 2019).

RESULTS

After medical record review, a cohort of 59 patients with acute lower extremity fracture in the setting of chronic SCI met all inclusion criteria and no exclusion criteria. Demographics and comorbidities were similar between groups with a median age of 46 years in the operative group and 47 years in the nonoperative group (P = 0.39). Twelve patients (70.6%) in the nonoperative group were male with 32 (76.2%) male patients in the operative group. Forty-six patients (78%) presented as low energy trauma and 12 (20%) as high energy. Seventeen patients (28.8%) were managed nonoperatively, whereas operative treatment was utilized for 42 patients (71.2%). Intramedullary nailing was the most common operative procedure, occurring in 38 (90%) operative cases.

On analysis of complications and outcomes, differences were seen between the operative and nonoperative group for pressure ulcers [19% (8/42) vs. 52.9% (9/17), P = 0.009] and mean VAS pain score at first follow-up (1.19 vs. 3.3, P = 0.03). No statistically significant difference was seen between operative and nonoperative management for rates of infection [14.3% (6/42) vs. 23.5% (4/17), P = 0.39], nonunion [2.4% (1/42) vs. 11.8% (2/17), P = 0.13], deep vein thrombosis (DVT) or pulmonary emobolus (PE) [4.8% (2/42) vs. 17.7% (3/17), P = 0.10], stroke [2.4% (1/42) vs. 0% (0/17), P = 0.52], amputation [2.4% (1/42) vs. 5.9% (1/17), P = 0.50], or death [4.8% (2/42) vs. 0% (0/17), P = 0.36]. Outcomes were similar between operative and nonoperative groups for return to baseline activity (mean of 4 vs. 6 months, P = 0.08) and ROM, with no ROM in 28.6% (12/42) operative versus 17.7% (3/17) nonoperative, limited ROM in 19.1% (8/42) operative versus 11.8% (2/17) nonoperative, and full ROM in 52.4% (22/42) operative versus 70.6% (12/17) nonoperative. Further illustration of all data can be found in Tables 1–4.

DISCUSSION

Patients with para- or quadriplegia after SCI have an increased risk for lower extremity long bone fractures secondary to their neurologic injury and decreased BMD.[4] The Orthopedic Trauma Association published clinical practice guidelines on lower extremity fractures in the setting of SCI and identified a lack of data available on this topic, ultimately recommending consideration for surgical treatment in these patients.[8] A recent systematic review has also identified insufficient evidence to support operative or nonoperative management as best practice for patients with SCI and lower extremity fracture.[9] To address this deficit, the authors present a cohort of 59 patients with SCI and lower extremity fractures to assess the impact of operative and nonoperative management. This cohort demonstrated that operative intervention was associated with a lower rate of pressure ulcers (19% vs. 52.9%, P = 0.009) and lower VAS pain scores (1.19 vs. 3.3, P = 0.03) when compared with those treated nonoperatively. These findings suggest that operative management for tibial and femoral shaft fractures may decrease morbidity for patients with chronic SCI who are inherently at increased risk

TABLE 1. Patient Characteristics (n = 59)

	Nonoperative (n = 17)	Operative (n = 42)	P
Age, median (IQR)	47 (20)	46 (19)	0.39
Sex (%)			0.65
Female	6 (29.4)	10 (23.8)	
Male	12 (70.6)	32 (76.2)	
Race (%)			0.98
White	15 (88.2)	32 (76.2)	
Other	2 (11.8)	10 (23.8)	
Comorbidities (%)			
Diabetes	2 (11.8)	5 (11.9)	0.98
Cardiovascular disease	3 (17.7)	7 (16.7)	0.92
Cancer	2 (11.8)	2 (4.8)	0.33
COPD	1 (5.9)	2 (4.8)	0.81
Dementia	0	1 (2.4)	0.53
Obesity	4 (23.5)	7 (16.7)	0.54
Smoking	4 (23.5)	20 (47.6)	0.08

for low energy fractures secondary to their bone's altered metabolism.

Current literature surrounding management of lower extremity long bone fractures in patients with chronic SCI is limited. Some studies report outcomes and mortality as similar between operatively and nonoperatively managed lower extremity fractures,[6,10] whereas other studies are conflicting regarding outcomes and complications.[7,11–13] In this cohort of 59 patients, mortality rates and union outcomes showed no difference, but rates of pain and pressure ulcers were significantly lower in those managed operatively. Much of the literature combines all lower extremity fractures into a single group when evaluating outcomes, but variation inherently exists among fracture types. Rate of union has shown to be affected by fracture characteristics, such as fracture classification and localization, with displaced proximal femur fractures developing nonunion regardless of treatment approach.[14] Contrasting this to our study of femoral and tibial shaft fractures, in which rates of nonunion were similarly less than 15%, collectively evaluating lower extremity fractures for differences between operative and nonoperative management may be inadequate.

The clinical impact of comorbidities on healing and patient outcomes should also be considered when evaluating these data. Comorbidities have been shown to increase the risk of amputation after lower extremity fracture in patients with a preexisting SCI.[13] Although no statistically significant differences surrounding comorbidities were observed in this study, sequelae were observed clinically. Literature has established the deleterious effects of SCI on lower extremity BMD and its subsequent impact on fracture risk.[2,3,15] This study's high number of low energy mechanism of injury may be a clinical representation of the underlying altered bone metabolism. Although not statistically significant, a difference was seen between operative and nonoperative management for infection rates, nonunion, DVT/PE, and amputation. The absolute percentages were at least half for nearly all of these outcomes and may be insignificant due to relatively low power with only 17 patients who were treated nonoperatively. Secondary outcome of VAS found differences in Minimum Clinically Important Difference (MCID) scores that are similar to MCID scores published for foot and ankle surgery and knee replacement surgery.[16,17] The calculated MCID scores have been reported in foot and ankle surgery to range from 1.8 to 5.2 points for VAS pain. In total joints, a statistically significant VAS has been reported to be improving −18.6 and −22.6 mm for total hip arthroplasty and total knee arthroplasty patients. These differences were in the same range of differences that was found between the operative and nonoperative groups.

TABLE 2. Injury Characteristics (n = 59)

	Nonoperative (n = 17)	Operative* (n = 42)	P
Mechanism (%)			0.18
Low energy	14 (82.4)	32 (66.2)	
High energy	2 (11.8)	10 (23.8)	
Gun shot wound	1 (5.9)	0	
Level of SCI (%)			0.97
Cervical	6 (35.3)	14 (33.3)	
Thoracic	10 (58.8)	25 (59.5)	
Lumbar	1 (5.9)	3 (7.8)	

*90.5% of the patients were treated using intramedullary nail fixation.

TABLE 3. Complications (%), n = 59

	Nonoperative (n = 17)	Operative (n = 42)	P
Infection	4 (23.5)	6 (14.3)	0.39
Pressure ulcers	9 (52.9)	8 (19)	0.009*
Nonunion	2 (11.8)	1 (2.4)	0.13
DVT/PE	3 (17.7)	2 (4.8)	0.10
Stroke	0	1 (2.4)	0.52
Amputation	1 (5.9)	1 (2.4)	0.50
Death	0	2 (4.8)	0.36

*Statistically significant P-value < 0.05.

TABLE 4. Outcomes (n = 59)

	Nonoperative (n = 17)	Operative (n = 42)	*P*
Range of motion (%)			0.44
No	3 (17.7)	12 (28.6)	
Limited of range	2 (11.8)	8 (19.1)	
Yes	12 (70.6)	22 (52.4)	
Pain scale VAS first follow-up, mean (SD)	3.3 (3.5)	1.19 (2.5)	0.03†
Return to baseline, median (IQR)*	6 (5)	4 (4)	0.08

*Measured in month.
†Statistically significant *P*-value < 0.05.

Limitations to this study include its retrospective nature and dependence on prior documentation. It was also not systematically determined if a decubitus ulcer was present or influenced decision making. A decubitus ulcer would certainly raise the risk of an operative infection and could be included in a larger study. Furthermore, focusing investigation specifically on shaft fractures of the femur and tibia weakened the statistical power. However, the authors believe focused studies like this are vital in determining treatment guidelines.

Further investigation is necessary surrounding lower extremity fractures in patients with SCI with need for specific, high-quality, multicenter randomized control trials or at least a prospective observational trial from which best practice recommendations can be established.

In this cohort of 59 patients with chronic SCI who sustained fractures of the femoral and tibial shaft, operative management yielded fewer complications and less pain compared with nonoperative methods with similar bony outcomes between the groups. Bony healing and mortality are important considerations, but patient experience can be greatly affected by any aspect of their healing process. This study suggests that there exists opportunity to decrease patient morbidity through operative management of femoral and tibial shaft fractures in this subset of orthopedic patients.

CONCLUSIONS

Tibial and femoral shaft fractures commonly result from low energy mechanisms in patients with chronic SCI. Operative treatment seemed to decrease morbidity in these patients via lower rates of pressure ulcers and decreased pain compared with nonoperative management.

REFERENCES

1. National Spinal Cord Injury Statistical Center. *Traumatic Spinal Cord Injury Facts and Figures at a Glance*. Birmingham, AL: University of Alabama at Birmingham; 2023.
2. Edwards WB, Schnitzer TJ, Troy KL. Bone mineral loss at the proximal femur in acute spinal cord injury. *Osteoporos Int.* 2013;24:2461–2469.
3. Eser P, Frotzler A, Zehnder Y, et al. Relationship between the duration of paralysis and bone structure: a pQCT study of spinal cord injured individuals. *Bone.* 2004;34:869–880.
4. Vestergaard P, Krogh K, Rejnmark L, et al. Fracture rates and risk factors for fractures in patients with spinal cord injury. *Spinal Cord.* 1998;36:790–796.
5. Carbone LD, Chin AS, Burns SP, et al. Morbidity following lower extremity fractures in men with spinal cord injury. *Osteoporos Int.* 2013;24:2261–2267.
6. Bethel M, Bailey L, Weaver F, et al. Surgical compared with nonsurgical management of fractures in male veterans with chronic spinal cord injury. *Spinal Cord.* 2015;53:402–407.
7. Fouasson-Chailloux A, Gross R, Dauty M, et al. Surgical management of lower limb fractures in patients with spinal cord injury less associated with complications than non-operative management: a retrospective series of cases. *J Spinal Cord Med.* 2019;42:39–44.
8. Carbone LD, Ahn J, Adler RA, et al. Acute lower extremity fracture management in chronic spinal cord injury: 2022 Delphi consensus recommendations. *JB JS Open Access.* 2022;7:e21.00152.
9. Huang D, Weaver F, Obremskey WT, et al. Treatment of lower extremity fractures in chronic spinal cord injury: a systematic review of the literature. *PM R.* 2021;13:510–527.
10. Frotzler A, Cheikh-Sarraf B, Pourtehrani M, et al. Long-bone fractures in persons with spinal cord injury. *Spinal Cord.* 2015;53:701–704.
11. Koong DP, Symes MJ, Sefton AK, et al. Management of lower limb fractures in patients with spinal cord injuries. *ANZ J Surg.* 2020;90:1743–1749.
12. Perkins C, Buck JS, Karunakar MA. Outcomes in the treatment of femur fractures in patients with pre-existing spinal cord injury. *Bull Hosp Jt Dis (2013).* 2019;77:211–215.
13. Elam RE, Ray CE, Miskevics S, et al. Predictors of lower extremity fracture-related amputation in persons with traumatic spinal cord injury: a case-control study. *Spinal Cord.* 2023;61:260–268.
14. Grassner L, Klein B, Maier D, et al. Lower extremity fractures in patients with spinal cord injury characteristics, outcome and risk factors for non-unions. *J Spinal Cord Med.* 2018;41:676–683.
15. Eser P, Frotzler A, Zehnder Y, et al. Assessment of anthropometric, systemic, and lifestyle factors influencing bone status in the legs of spinal cord injured individuals. *Osteoporos Int.* 2005;16:26–34.
16. Sutton RM, McDonald EL, Shakked RJ, et al. Determination of Minimum Clinically Important Difference (MCID) in Visual Analog Scale (VAS) Pain and Foot and Ankle Ability Measure (FAAM) Scores after Hallux Valgus Surgery. *Foot Ankle Int.* 2019;40:687–693.
17. Danoff JR, Goel R, Sutton R, et al. How much pain is significant? Defining the minimal clinically important difference for the visual analog Scale for pain after total joint arthroplasty. *J Arthroplasty.* 2018;33:S71–S75.e2.

