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Implementation of a Dedicated Orthopaedic Trauma Room in Hip and Femur Fracture Care: A 17-Year Analysis

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Objective: To examine the effects of implementing a dedicated orthopaedic trauma room (DOTR) on hip and femur fracture care.

Design: A retrospective cohort study. Setting: Level 1 trauma center. Patients: 2928 patients with femoral neck, pertrochanteric, and femoral shaft and distal femur (FSDF) fractures.

Intervention: Implementation of a DOTR.

Main Outcome Measures: Hospital length of stay (LOS), emergency department (ED) LOS, intensive care unit (ICU) LOS, and time to operating room (TTOR).

Results: Implementation of a DOTR resulted in significant improvement in TTOR for all patient groups ($P < 0.05$). We found shorter TTOR for pertrochanteric ($P < 0.001$), femoral neck ($P = 0.039$), and FSDF groups ($P = 0.046$). Total hospital LOS was shorter for patients with pertrochanteric ($P < 0.001$) and femoral neck fractures ($P = 0.044$). Patients with pertrochanteric hip fractures demonstrated shorter ICU LOS ($P < 0.001$). No LOS improvements were observed among patients in the FSDF group. ED LOS was significantly longer in all patient groups ($P < 0.001$).

Conclusions: Implementation of a DOTR was associated with shorter TTOR, shorter hospital and ICU LOS, and longer ED LOS. There was a greater number of patients transferred into the investigating institution and fewer patients transferred out. These data support the utility of a DOTR as it relates to an improvement in hospital stay–related outcomes in patients with fractures of the hip and femur. Our results suggest that a DOTR in a Level I trauma hospital is associated with improvement in patient care.

Key Words: dedicated trauma room, time to OR, trauma database, length of stay, hip fracture

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

The dedicated orthopaedic trauma room (DOTR) has been shown to improve workflow while reducing the complications and costs that are associated with musculoskeletal trauma care.[1] Coupled with this, recent evidence has demonstrated that the availability of a DOTR has become a best practice for orthopaedic trauma care.[1] Studies have suggested nonemergency or complex cases should be treated during daytime hours in DOTRs with their usual staff.[2]

Trauma centers and orthopaedic surgeons have traditionally been faced with limited operating room availability for fracture surgery. Orthopaedic trauma cases are often waitlisted and completed after elective cases have concluded. Studies have investigated that the availability of a DOTR reduced nighttime cases and subsequently allowed for a reduction in treatment delay and morbidity.[3] Other advantages with trauma room implementation include improvements in morbidity and complication rates, decreased intensive care unit (ICU) admissions, fewer unplanned surgeries, improved noncomplicated fracture union, enhancements in the professional and personal lifestyles of the on-call surgeon, and increased surgeon recruitment and retention.[3–6]

Decreasing the time to operating room (TTOR) for hip fractures has been of particular interest to orthopaedic surgeons.[7–9] Improved morbidity and mortality outcomes have been associated with earlier hip fracture surgery.[10] The current AAOS evidence-based guidelines on the management of geriatric hip fractures state that hip fracture surgery within 48 hours of admission is associated with better outcomes.[11,12]

A trauma registry has been in existence at our institution since 2004. In 2013, a DOTR was made available for the treatment of fractures and has been used daily since implementation (07:30–17:00). We sought to examine outcome measures for pertrochanteric, femoral neck, and femoral shaft and distal femur (FSDF) fractures between 2004 and 2020 as they relate to the introduction of a DOTR in 2013.

METHODS

Data were obtained from our institution's trauma regis-

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groups (femoral neck, pertrochanteric, and FSDF) between May 2009 and December 2016. We included all modes of treatment for these patients, including open reduction internal fixation, intramedullary fixation, and hemiarthroplasty when performed. This represents 4 years before and 4 years after the implementation of the DOTR. TTOR was computed as the time elapsed in hours between ED admission and surgery start time.

RESULTS

There were 1081 patients treated during the pre-DOTR period and 1847 in the post-DOTR implementation period. The patient population in the post-DOTR period included a significantly higher proportion of female patients ($P < 0.001$), non-Black patients ($P < 0.001$), and patients older than 65 years ($P < 0.001$). Patients also had more underlying risk factors in the post-DOTR period. In the post-DOTR period, a higher proportion of patients were transferred in from other hospitals ($P < 0.001$) and fewer were transferred out to other hospitals ($P < 0.001$) (Table 2). In the post-DOTR period, there was also a shorter hospital LOS ($P < 0.001$), decrease in ICU LOS ($P < 0.001$), and longer ED LOS ($P < 0.001$) for the pertrochanteric group. Within the subsample for which TTOR data were available, the mean time was significantly shorter for all groups in the post-DOTR period (Table 3).

Results for inpatient mortality and LOS outcomes for patient subgroups were analyzed (Table 3). After controlling for age, sex, race, risk factors, and ISS, inpatient mortality rates were not found to be significantly lower after implementation of a DOTR for femoral neck fractures ($P = 0.205$), pertrochanteric hip fractures ($P = 0.986$), and FSDF fractures ($P = 0.651$). Overall LOS was significantly lower for femoral neck fractures ($P = 0.044$) and pertrochanteric hip fractures ($P < 0.001$), but not for FSDF fractures ($P = 0.837$). ED LOS was longer after implementation of a DOTR for all groups (Table 4).

The TTOR was decreased by 6.2 hours on average in the post-DOTR period (Table 3). After controlling for demographics, surgical risk, and ISS, subgroup analysis demonstrated a decrease in TTOR of 16.7% (1.6 hours), 9.4% (6.2 hours), and 13.7% (3.6 hours) for pertrochanteric hip, femoral neck, and FSDF, respectively, when comparing the pre-DOTR and post-DOTR periods (Table 5).

DISCUSSION

The DOTR has changed the flow of fracture care as it has evolved over the past 20 years.[1,3,4,6,14–19] Our institution,

TABLE 2. Descriptive Statistics of Demographics, Injury Characteristics and Severity, Transfers, and ICU Admissions

Patient Demographics	Pre-DOTR (N = 1081)	Post-DOTR (N = 1847)	P
Sex			<0.001
Male	607 (56.2%)	852 (46.1%)	—
Female	474 (43.9%)	995 (53.9%)	—
Race			<0.001
Black	558 (51.6%)	756 (40.9%)	—
Non-Black	523 (48.4%)	1091 (59.1%)	—
Age			
<18 y	168 (15.5%)	140 (7.6%)	—
18–39 y	280 (25.9%)	295 (16.0%)	—
40–64 y	220 (20.4%)	356 (19.3%)	—
65 + y	413 (38.2%)	1056 (57.2%)	—
Risk factors			
No risk factors	603 (56.8%)	727 (39.4%)	—
1 risk factor	259 (24.0%)	513 (27.8%)	—
>1 risk factor	219 (20.3%)	607 (32.9%)	—
Injury characteristics			
Pertrochanteric	284 (26.3%)	733 (39.7%)	<0.001
Femoral neck	161 (14.9%)	492 (26.6%)	<0.001
Femoral shaft distal femur	657 (60.8%)	684 (37.0%)	<0.001
Injury Severity Score			0.005
0–9	12 (1.1%)	3 (0.2%)	—
10–15	961 (88.9%)	1638 (88.7%)	—
16–25	60 (5.6%)	110 (6.0%)	—
26+	48 (4.4%)	96 (5.2%)	—
Transfers			
Transferred in	57 (5.3%)	173 (9.4%)	<0.001
Transferred out	48 (4.5%)	8 (0.4%)	<0.001

patients presenting for treatment in the emergency department (ED) for traumatic injury. Registry records were obtained from January 1, 2004, to December 30, 2020. Patients with one or more of the following diagnoses were included: femoral neck fracture, pertrochanteric hip fracture, or FSDF fracture. Analyses were conducted using deidentified patient data. This study was certified as exempt from review by the institutional review board.

Trauma Room Period Classification

Patients with ED arrival dates before January 20, 2013, were classified as part of the pre-DOTR implementation period. Patients with arrival dates on or after that date were classified as within the post-DOTR implementation period.

Injury Type

Injuries were screened and classified based on *ICD-9* (for dates before October 1, 2015) or *ICD-10* diagnostic codes (Table 1). Patients with pertrochanteric hip fracture (extracapsular proximal femur fractures affecting the greater and lesser trochanters) were identified as those with *ICD-9* diagnosis codes beginning with 820.2 or 820.3, or with *ICD-10* diagnosis codes beginning with S72.1 or S72.2. Patients with femoral neck fracture were identified as those with *ICD-9* diagnosis codes beginning with 820.0, 820.1, 820.8, or 820.9, or with *ICD-10* diagnosis codes beginning with S72.0. Patients in the FSDF group were identified as those with *ICD-9* diagnosis codes beginning with 821 or *ICD-10* diagnosis codes beginning with S72.3, S72.4, S72.8, or S72.9.

Transfer Status

Patients recorded in the registry to have been transferred from another hospital were defined as having been transferred in. Patients who were transferred to another hospital were defined as having been transferred out.

Risk Factors

Patient risk factors recorded in the registry included asthma, cancer, coronary artery disease, current chemotherapy treatment, congestive heart failure, cerebrovascular accident, dialysis treatment, diabetes, hypertension, renal disease, seizure disorders, and warfarin/Coumadin treatment. A risk scale was constructed by computing the sum of the number of these risk factors applicable for each patient.

Injury Severity and Patient Condition

Injury severity was measured using the Injury Severity Scale (ISS).[13] The ISS is determined on the basis of injury severity ratings for each body region and is scored on a scale from 0 to 75, with higher scores indicating more severe injury.

Outcomes

Outcomes assessed included mortality, TTOR, ICU length of stay (LOS), ED LOS, total hospital LOS, and final hospital disposition. Both the ICU and hospital LOS were measured in days, TTOR in hours, and ED LOS in minutes. Final dispositions were coded as left against medical advice, death in the ED, death after admission to the hospital floor, home health care, other medical institutions (eg, long-term care facility), routine discharge (eg, home), or transfer to another hospital. Demographic information collected for patients included sex, race, and age. Because almost all patients in this sample were either Black or White, race was coded dichotomously as Black or non-Black.

Time to the Operating Room

Data regarding the time between ED admission and initiation of orthopaedic surgery were not included in the trauma registry but were available from other administrative data for a subset of patients who were treated from the 3

TABLE 1. Summary With Description of *ICD-9* and *ICD-10* Diagnosis Codes by Fracture Group

Group	ICD Edition	Diagnosis Code	Description
Pertrochanteric hip fracture	*ICD-9*	820.2	Pertrochanteric fracture of femur closed
		820.3	Pertrochanteric fracture of femur open
	ICD-10	S72.1	Pertrochanteric fracture
		S72.2	Subtrochanteric fracture of femur
Femoral neck fracture	*ICD-9*	820	Fracture of neck of femur
		820.0	Transcervical fracture closed
		820.1	Transcervical fracture open
		820.8	Closed fracture of unspecified part of neck of femur
		820.9	Open fracture of unspecified part of neck of femur
	ICD-10	S72.0	Fracture of head and neck of femur
FSDF (femoral shaft and distal femur)	*ICD-9*	821.0	Fracture of shaft of femur closed
		821.1	Fracture of shaft of femur open
		821.2	Fracture of lower end of femur closed
		821.3	Fracture of lower end of femur open
	ICD-10	S72.3	Fracture of shaft of femur
		S72.4	Fracture of lower end of femur
		S72.8	Other fracture of femur
		S72.9	Unspecified fracture of femur

TABLE 3. Descriptive Statistics of Final Disposition, Mean TTOR, and LOS

	Pre-DOTR (N = 1081)	Post-DOTR (N = 1847)	*P*
Final disposition			
Left against medical advice	2 (0.2%)	6 (0.3%)	0.484
Death in ED	27 (2.5%)	38 (2.1%)	0.435
Death on floor	20 (1.9%)	53 (2.9%)	0.088
Home health	110 (10.2%)	176 (9.5%)	0.569
Institution	462 (43.1%)	1128 (61.1%)	<0.001
Routine discharge	404 (37.9%)	437 (23.6%)	<0.001
TTOR and LOS			
Mean TTOR (hours) [SD]*	33.4 [34.2]	27.2 [27.5]	0.010
ICU LOS (d) median [IQR]	3.0 [2.0, 7.0]	3.0 [2.0, 6.0]	0.584
ED LOS (hours) median [IQR]	5.4 [3.7, 7.4]	5.8 [4.4, 8.2]	<0.001
Hospital LOS (d) median [IQR]	5.0 [3.0, 7.0]	5.0 [3.0, 7.0]	0.163

IQR, interquartile range.
Significance tests are derived from χ^2 tests for all categorical variables; the *t* test for the means of the log-transformed door to operating room time; and Mann–Whitney *U* tests for ICU, ED, and hospital LOS.
*TTOR is available for a subset of patients between May 2009 and December 2016 (pre-DOTR N = 179; post-DOTR N = 388).

a Level 1 trauma center, implemented a DOTR in 2013. This was associated with several significant improvements in key outcomes, including shorter TTOR for all subgroups and a shorter hospital, ICU, and ED LOS in some subgroups. A shorter hospital LOS after hip fracture fixation has been shown to improve patient outcomes.[20] Thus, there is an interest in methods to lower patient hospital LOS after hip fracture to benefit patient outcomes and control costs for the treating institution.[21] Other studies indicate that shorter TTOR and LOS reduces 1-year mortality, suggesting the potential for longer-term benefits not captured by our investigation.[7–9,22]

In addition, a recent study found that hip fracture repair occurring during "out-of-hours" (17:00–08:00) was associated with a 5% increase in 30- and 90-day mortality risk compared with "on-hour" (08:00–17:00).[23] We recognize that measuring in-hospital mortality is a distinctly different assessment than measuring 30- and 90-day postoperative mortality rates associated with hip fracture care. In-hospital mortality, which was looked at in our study, represents only a limited sample of patients experiencing mortality after hip fracture surgery. Although we wanted to include outpatient mortality data in our study, we lacked the ability to retrospectively review 30- and 90-day mortality rates for our pre-DOTR group. Future studies are needed to look at reducing these mortality rates as it relates specifically to the introduction of a DOTR.

As mentioned previously, recent consensus concluded that a shorter TTOR and LOS is beneficial[7–9,20,22]; however, we believe this article is the first to suggest how to get these times to decrease. Although it is possible that the decreases we observed at our institution may have resulted from multiple factors, the authors believe that the DOTR used explicitly for fracture management was the primary factor influencing these results. The AAOS guidelines emphasize that geriatric hip fractures managed within 48 hours are associated with better outcomes [11,12]; we were able to observe a decrease in TTOR in pertrochanteric (6.2 hours) and femoral neck fractures (1.6 hours). Although the clinical relevance of this

TABLE 4. Summary of Adjusted Model Results for Differences in Patient Outcomes After Introduction of DOTR Within Patient Subgroups

Patient Sample	Mortality OR [95% CI]	ICU LOS RR [95% CI]	ED LOS RR [95% CI]	LOS RR [95% CI]
Pertrochanteric hip fractures (n = 1018)	0.99 [0.41, 2.42] *P* = 0.986	0.71 [0.61, 0.83] *P* < 0.001	1.29 [1.23, 1.35] *P* < 0.001	0.86 [0.81, 0.90] *P* < 0.001
Femoral neck fractures (n = 655)	0.52 [0.19, 1.43] *P* = 0.205	0.85 [0.69, 1.06] *P* = 0.147	1.74 [1.63, 1.86] *P* < 0.001	0.93 [0.86, 0.99] *P* = 0.044
FSDF fractures (n = 1341)	1.15 [0.62, 2.15] *P* = 0.651	1.71 [1.53, 1.90] *P* < 0.001	1.20 [1.15, 1.26] *P* < 0.001	1.00 [0.95, 1.04] *P* = 0.837

OR, odds ratio; RR, relative risk.
All models include controls for age, sex, race, risk factors, and ISS.

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We also analyzed hospital transfer activity as it relates to our DOTR start date. Not only were there significantly more patients transferred into the hospital but there were also fewer patients transferred out. As a hospital, there were 57 (5.3%) patients transferred into our hospital before DOTR implementation versus 173 (9.4%) patients transferred into our hospital after the DOTR implementation ($P < 0.001$). Patients transferred out of the hospital included 48 (4.5%) pre-DOTR versus 8 (0.4%) post-DOTR implementation ($P < 0.001$). This was a net result of 9 transferred in versus 165 transferred in between pre-DOTR and post-DOTR (Table 3). Although it is difficult to measure factors for the increased transfer volume seen in our study, it is likely multifactorial and may be attributed to increased administrative and physician awareness within the local 6 hospital system. Further studies to determine the nuances of these transfers may reveal further financial benefits of a DOTR.

Another potentially confounding variable may be the addition of 2 orthopaedic trauma surgeons who were employed 4 months before the implementation of the DOTR, potentially decreasing the transferred out patients. This would potentially keep higher complexity injuries and polytrauma patients who may have been transferred previously. However, when ISS scores were compared between the pre-DOTR versus post-DOTR transfers, no statistically significant difference was seen.

Another area of interest is the increase in ED LOS. Although the difference was significant, the median ED LOS was only about 12 minutes (<10%) longer in the post period, which seems minor from a clinical perspective. This increase could be explained by the increased number of procedures (eg, traction pin placement, reductions, and trauma workup) being performed, resulting in longer ED times after the implementation of the trauma room.

One of the aims of this article is to look at a fracture population as it relates to a DOTR decreasing the TTOR for 3 different subtypes of femur fractures. Two of these groups were made up of geriatric hip fractures. As a comparison group, we also analyzed a separate FSDF group, which, unlike the hip fracture groups, were on average younger patients with a higher ISS score (see **Table, Supplemental Digital Content 1**, http://links.lww.com/JOT/B734). We find this FSDF group a useful comparison group to include alongside our elderly hip fracture groups for a more complete image of DOTR implementation.

Our findings also showed that hospital LOS was lower after implementing the DOTR for both hip fracture groups and not the FSDF fracture group. We are not aware of any prioritization given to treating these elderly hip fractures in the trauma room. No separate geriatric hip fracture service exists at our hospital. However, it is worth noting that these are quite different groups. (see **Table, Supplemental Digital Content 1**, http://links.lww.com/JOT/B734). Associated non-orthopaedic injuries might explain the observed increase in ICU LOS among patients in the FSDF group. With these higher-energy injuries, one might expect longer lengths of stay on the whole.

Another potential limitation of our study is that there is no way to account for the variability of the individual surgeons covering the trauma room. Along with the implementation of the trauma room in 2013, the hospital hired 2 orthopaedic trauma surgeons. Previous studies have shown significantly decreased operative times, surgical labor expenses, supply costs, and implant costs by the fellowship-trained group representing enhanced control of the design, plan, execution, and monitoring of orthopaedic trauma care.[2] It is possible that the DOTR, in addition to the orthopaedic trauma surgeons who covered it after its implementation, worked synergistically to give the statistically significant results seen in our study. However, it is important to note that the institution did have orthopaedic trauma surgeons operating before the implementation of the DOTR. In addition, in the post-DOTR period, orthopaedic trauma surgeons were not the only surgeons covering the trauma room, included were orthopaedic surgeons from 5 other orthopaedic subspecialties. The surgeons covering the call schedule both before and after the DOTR were a heterogenous group of surgeons representing many orthopaedic subspecialties including orthopaedic trauma.

It is also important to consider the availability and timeliness of the on-call surgeon using the DOTR to perform more surgical procedures in addition to their elective practice. We would assume that this factor was similar both before and after the implementation of the DOTR at our institution. Specifically, during the entire 17-year period of this study, the on-call surgeons had practices consisting of both elective and trauma call cases. It is difficult to measure how different specialty trained orthopaedic surgeons may triage an elderly

TABLE 4. Summary of Adjusted Model Results for Differences in Patient Outcomes After Introduction of DOTR Within Patient Subgroups

Patient Sample	Mortality OR [95% CI]	ICU LOS RR [95% CI]	ED LOS RR [95% CI]	LOS RR [95% CI]
Pertrochanteric hip fractures (n = 1018)	0.99	0.71	1.29	0.86
	[0.41, 2.42]	[0.61, 0.83]	[1.23, 1.35]	[0.81, 0.90]
	$P = 0.986$	$P < 0.001$	$P < 0.001$	$P < 0.001$
Femoral neck fractures (n = 655)	0.52	0.85	1.74	0.93
	[0.19, 1.43]	[0.69, 1.06]	[1.63, 1.86]	[0.86, 0.99]
	$P = 0.205$	$P = 0.147$	$P < 0.001$	$P = 0.044$
FSDF fractures (n = 1341)	1.15	1.71	1.20	1.00
	[0.62, 2.15]	[1.53, 1.90]	[1.15, 1.26]	[0.95, 1.04]
	$P = 0.651$	$P < 0.001$	$P < 0.001$	$P = 0.837$

OR, odds ratio; RR, relative risk.
All models include controls for age, sex, race, risk factors, and ISS
OR or RR >1.0 indicates higher likelihood in post-DOTR period; OR or RR <1.0 indicates lower likelihood in post-DOTR period.

TABLE 5. Summary of Adjusted Model Results for Differences in Door to Operating Room Time After Introduction of a Dedicated Orthopaedic Trauma Room, Within Patient Subgroups

Patient Sample	Pre/Post Period Differences (hours)	Pre/Post Period Difference % [95% CI]	Regression Coefficient b [SE]	P
Pertrochanteric hip fractures (n = 292)	−1.6	−16.7% [−9.7%, −23.2%]	−0.18 [0.04]	<0.001
Femoral neck fractures (n = 180)	−6.2	−9.4% [−0.5%, −16.8%]	−0.09 [0.05]	0.039
FSDF fractures (n = 109)	−3.6	−13.7% [−0.3%, −25.3%]	−0.15 [0.07]	0.046

Analyses are based on a log transformation of the total door to operating room hours. All models include controls for age, sex, race, risk factors, and ISS.

hip fracture or polytrauma patient and what their independent availability may be.

Another potential weakness of our study that we recognize is that within our 17-year time frame of 2004–2020 much has been published regarding an emphasis on early hip fracture care. Although difficult to pinpoint, it is possible that improved awareness influenced our overall DTOR times. We believe it is important to recognize there may be factors, which are difficult to measure, that would influence a trend toward earlier hip fracture surgery during this lengthy 17-year period.

CONCLUSIONS

To the best of our knowledge, this is the first article to look specifically at the outcomes of TTOR, LOS, and the volume of patients transferred to an institution after implementing a DOTR for the treatment of hip and femoral fractures. We found that the TTOR was significantly decreased in the post-DOTR period for all 3 groups. After controlling for patient demographics and trauma severity, patients treated for pertrochanteric and femoral neck fractures had a shorter ICU and total hospital LOS after DOTR implementation. There were no significant differences between periods for risk of inpatient mortality. The implementation of the DOTR also correlated with a statistically significant increase in patient transfers into our institution and a decrease in patients transferred out. Although not directly studied in this investigation, there is evidence to link the observed difference in TTOR and hospital LOS to improved patient outcomes and decreased overall treatment cost.

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