

Race and Ethnicity Has a Mixed Effect on the Treatment of Tibial Plateau Fractures

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1

2 Abstract

3 **Objectives:** To determine if racial or economic disparities are associated with short term
4 complications and outcomes in tibial plateau fracture care.

5 **Design:** Retrospective cohort study

6 **Setting:** All New York State hospital admissions from 2000 to 2014, as recorded by the New
7 York Statewide Planning and Research Cooperative System database

8 **Patients/Participants:** Thirteen thousand five hundred eighteen inpatients with isolated tibial
9 plateau fractures (AO/OTA 44), stratified in four groups: Caucasian, African-American,
10 Hispanic, and Other.

11 **Intervention:** Closed treatment and operative fixation of the tibial plateau

12 **Main Outcome Measurements:** Hospital LOS (days), in-hospital complications/mortality,
13 estimated total costs, and 30-day readmission

14 **Results:** There were no significant differences with regard to in-hospital mortality, infection,
15 deep vein thrombosis/ pulmonary embolism (DVT/PE), or wound complications between races,
16 even when controlling for income. There was a higher rate of non-operatively treated fractures in
17 the racial minority populations. Minority patients had on average 2 days longer length of stay
18 (LOS) compared to Caucasians ($p<0.001$), costing on average \$4,000 more per hospitalization
19 ($p<0.001$). Multivariate logistic regression found that neither race nor estimated median family
20 income were independent risk factors for readmission.

21 **Conclusions:** While nature of initial injury, use of external fixator, comorbidity burden, age,
22 insurance type and LOS were independent risk factors for readmission, race and estimated
23 median family income were not. In patients who sustained a tibial plateau fracture, race and

ethnicity seemed to affect treatment choice, but once treated racial minority groups did not demonstrate worse short term complications, including increased mortality and postoperative readmission rates.

Key Words: Racial disparities; tibial plateau; fracture; short term outcomes; trauma

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

Introduction

Racial disparities have been demonstrated throughout the American healthcare system. [1] Biases and barriers surrounding access to care have led to poorer quality and reduced quantity of appropriate health care delivery to minority patients [2–5], resulting in worse overall outcomes in these populations.[6,7] **As a result of these reports, an effort to address healthcare disparities has been instituted by the Accreditation Council for Graduate Medical Education (ACGME) which now mandates residency programs to integrate healthcare disparity education into their surgical training curriculum.** While there have been reports in the orthopaedic literature examining outcomes as they pertain to healthcare disparities, there has been insufficient evidence to support generalization to the entire field. [8] The majority of published works in the orthopaedic literature have instead focused on how racial health disparities affect algorithms regarding treatment and decision-making, with a subsequent focus on complication rates in either spine surgery or joint replacements. [8–12]

Currently, there is limited data evaluating racial health disparities in orthopaedic trauma. Unlike elective procedures, trauma patients are treated on an emergent basis, resulting in a theoretical reduction in biases regarding when and for whom a surgical procedure will be

performed. The few studies pertaining to this subject are small series reporting equivocal outcomes, thus providing minimal utility regarding our understanding of disparities in orthopaedic trauma. [13,14] To our knowledge, larger database trauma registries have not been utilized to examine if differences in short-term outcomes between racial and ethnic groups following orthopaedic lower extremity trauma exist.

To better understand potential disparities, we utilized a large statewide hospital inpatient database to determine **whether differences in short term-term complications and hospital readmissions following tibial plateau fracture varied based upon patient race and socioeconomic status.** We hypothesized that although patient and injury characteristics may differ according to race at initial presentation, short-term outcomes would not demonstrate any racial disparities.

Methods

Access to a de-identified version of the New York Statewide Planning and Research Cooperative System (SPARCS) database, which maintains records for all patients hospitalized in the New York State, was obtained from the Department of Health. This registry has consistently been proven to be a reliable source in the orthopaedic literature. [15–19] Similar to previous methodology, International Classification of Diseases (ICD)-9 codes 823.0-823.12 were used to identify all patients hospitalized after sustaining a tibial plateau fracture. [20] From there, both patients treated non-operatively (79.06) and operatively with open reduction internal fixation (ORIF) (ICD-9 79.36) ± external-fixator (78.17) were included.

Race was stratified into four groups: Caucasian, African-American, Hispanic, and Other.

Other patient characteristics, including age, gender, insurance type, and injury characteristics were compiled and queried using SAS® 9.3 (Cary, NC). Patient comorbidities were also collected and evaluated by the Elixhauser Comorbidity Scale, which has been demonstrated to have high reliability in orthopaedic registry analysis. [21] All identified comorbidities were summed, and overall comorbidity burden was stratified into four groups: 0, 1, 2, and 3 or more comorbidities. As a proxy for socioeconomic status, patient zip codes were used to estimate median family income for these patients via US census data. [23,24]

In-hospital outcomes, complications, and 30 day readmission rates were determined for all patients. In-hospital outcomes included mean length of stay (LOS) in days, total hospital costs, in-hospital mortality, and in-hospital complications (ranging from wound complications, thromboembolic disease, infection, and post op delirium). Estimated total costs for each hospitalization were calculated by using Medicare data to create a “cost to charge ratio” (operating CCR + capital CCR) for each individual hospital and year, and then multiplying to total charges obtained from the SPARCS database. [22] Thirty-day readmission rates were also examined, with primary ICD-9 diagnosis at time of readmission serving as indication for etiology of readmission. Of note, those patients who underwent planned staged fixation following external fixation were not counted as readmissions.

Over a 15-year period (January 2000 through December 2014), we identified 13,518 admissions for patients undergoing operative repair of a tibial plateau fracture. Caucasians made up the highest proportion of patients at 60.9%. 17.9% of the patients were African-American, 9.6% of Hispanic origin, and 11.7% were from all other races. The Caucasian cohort was significantly older and predominantly female as compared to all other races (Table 1). They also tended to have higher estimated incomes and rates of private insurance, while minority patient

groups had a higher proportion of Medicaid as their primary form of reimbursement. Caucasians tended to have more medical comorbidities during their index admission. Additionally, African-Americans had higher rates of obesity, with 6.0% having a BMI>30 as compared to 5.7% of Caucasians, 5.7% of Hispanics, and 3.8% of the other races (p=0.03). Initial injury characteristics also significantly varied between the different racial cohorts. Minority patient groups demonstrated the highest rates of open fractures and treatment with external fixators (Table 1).

Shapiro-Wilk test was performed demonstrating that the four cohorts were normally distributed before univariate analysis was performed. Univariate analysis was completed using chi-square test for dichotomous variables and ANOVA analysis when comparing means between multiple groups. A multivariate logistic regression model was created controlling for age, sex, race, insurance type, open fracture, use of an external fixator, comorbidity burden, discharge disposition and LOS to determine independent risk factors for 30-day readmission. Post regression diagnostics were performed and the continuous independent variables in this analysis were linearly related to the logit of the dependent variable. A multiple regression was also run to predict LOS from age, race, open fracture, use of an external fixator, and comorbidity burden, and discharge disposition. The assumptions of linearity, independence of errors, homoscedasticity, and normality of residuals were met in this model. P values <0.05 were considered significant for all statistical analyses. Institutional review board approval was not required for this study because no human subjects were contacted.

Results

Of our study population, 13,518 patients sustained a tibial plateau fracture. African

Americans and Hispanics (Racial Minority) were more likely to undergo non-operative treatment at a rate of nearly 10% of the 1140 patients, compared to 8.2% seen in Caucasian ($p=0.01$, Table 2). Racial minority patients had on average 2 days longer LOS compared to Caucasians (8.4 days vs 6.4 days, $p<0.001$). Caucasians therefore had, on average, the least expensive hospitalization, costing approximately \$4,000 less than the other cohorts. Caucasians were also more likely than all other races to have non-homebound discharge disposition after ORIF of their tibial plateau fracture ($p<0.001$). No significant differences were found in in-hospital mortality, any infection, deep vein thrombosis/pulmonary embolism (DVT/PE), or wound complications (Table 2). Caucasians were found to have a greater rate of postoperative complications ($p<0.001$), with a higher rates of transfusions and postoperative delirium than all other races.

A multiple regression analysis was performed examining predictors of increased length of stay. Age, race, estimated median family income, use of external fixator, comorbidity burden, and discharge disposition were all statistically significant predictors of hospital length of stay, $F(9,11876) = 311.104$, $p<0.001$. Regression odds ratios, standard errors, and 95% confidence intervals can be found in Table 3. Racial minority status continued to be an independent predictor of increased hospital length of stay.

1,047 patients (7.7%) were readmitted to a hospital within 30 days after their discharge for a tibial plateau fracture. Thirty day readmission rates did not significantly vary between racial or ethnic groups (Table 4). Caucasians were most likely to return back for treatment of either thromboembolic disease or anemia. African Americans and other minority patients were more likely to return to receive antibiotics for an infection (the database does not specify whether this was a wound infection or other diagnosis however) on their hospital readmission ($p=0.03$).

Multivariate logistic regression was performed controlling for age, sex, race, estimated

median family income, insurance type, open fracture, fixation type, comorbidity burden, discharge disposition and LOS to determine independent risk factors for 30-day readmission. Independent risk factors for hospital readmission included open fractures (OR: 1.6; 95% CI 1.26-2.05, $p<0.001$), external fixator use (OR: 1.25; 95% CI 1.02-1.54, $p<0.001$), 3 or more comorbidities (OR: 1.88; 95% CI 1.56-2.28, $p<0.001$), older age (OR: 1.01; 95% CI 1.00-1.01, $p<0.001$), Medicare insurance (OR:1.49; 95% CI 1.12-1.99, $p=0.006$), Medicaid (OR:1.35; 95% CI 1.00-1.82, $p=0.05$) and additional extra day in hospital stay (OR: 1.01 95% CI 1.01-1.02, $p<0.001$). Race was not found to be an independent predictor for 30-day readmission.

Discussion

It is of national interest for the US healthcare system to eliminate racial disparities. [1,33,34] Accreditation Council for Graduate Medical Education (ACGME) requirement to integrate disparity education into their surgical training curriculum emphasizes its importance. [35] In this study of short-term outcomes, readmissions and quality measures following treatment of tibial plateau fractures, we found limited associations between patient race and outcomes. Our results suggest that these disparities do not become evident in orthopaedic trauma patients until the later subacute phase of injury, if present at all. The question of variation in outcomes for orthopaedic surgery by racial or ethnic categorization has yet to be fully elucidated. To date, the most widely surveyed orthopaedic subspecialties have been in spine and joint arthroplasty.[8] Nwachukwu et al conducted a systematic review of nine studies examining early postoperative outcomes after total hip and knee replacements, reporting a higher risk for early complications, most notably joint infection, in African-American and Hispanic populations.[25] A recent meta-analysis of eleven spine studies found that 10.4% of non-whites

sustained an unfavorable outcome as compared to only 9.4% of white patients. [26] It is important to note that only three of the included articles were able to appropriately control for the effects of health insurance and socioeconomic status. Therefore, although results from both of these studies suggest health care disparities in orthopaedic surgery outcomes, we are cautious to draw definitive conclusions regarding the effect of race on all orthopaedic outcomes.

The literature focusing on outcome by patient racial identity in orthopaedic trauma is even more limited. Compared to most other orthopaedic specialties, orthopaedic trauma provides a unique perspective through which to examine health care disparities. **Typically, these patients have injuries that have clear cut treatment indications that are not dictated by ethnicity or socioeconomic status, but instead based solely on factors related to the presenting injury and health status.** This prompt management pattern, seemingly eliminating possible bias, can also be seen in emergent general surgery. A study that examined mortality in the National Trauma Data Bank found that race and insurance status independently predicted worse outcomes after trauma. However, they were not able to control for hospital level factors (i.e. volume of the trauma census). [27] At the same time, Causey et al. looked at 75,000 patients who underwent emergent abdominal surgery in the NSQIP database, and found no mortality differences between African Americans and Caucasians.[28] Similar to these types of procedures, tibial plateau fixation also tends to be performed without a significant delay time between evaluation and operation. Piposar et al. designed a report to primarily address how race affects tibial shaft short-term outcomes. Similar to our results, the authors found significant differences in severity of fracture between racial cohorts. Specifically, they found that minority patients were more likely to have open fractures and sustain gunshot wounds. However, hospital mortality and the readmission for infection rates did not vary between these populations.¹¹ Results from the latter

study are consistent with the presented analysis, where mortality and overall 30 day readmission were essentially equal between Caucasians, African Americans, Hispanics, and other minorities. While Walsh et al. were able to show racial disparities in long term outcomes in orthopaedic trauma [29], this is the first paper, to our knowledge, to use a large statewide database to examine short term complications in lower extremity trauma.

Although this report demonstrates that many racial disparities are limited in the treatment of tibial plateau fractures, there was higher incidence of non-operative treatment in minority populations (Table 2). A study by Neuman et al similarly found an elevated rate of non-operative treatment after hip fracture in their African American cohort, with a 79% increase in odds in comparison to Caucasians. [36] However, a recently published work by Dy et al, also examining hip fracture treatment, did not note any variations in treatment modality between racial cohorts, rather finding that racial minorities were only more likely to have a delay in treatment. [37] When examining at ankle fractures, Koval et al found that older age, comorbidities, female gender, and more complex fracture patterns resulted in higher rates of non-operative treatment, but no differences between Caucasians and minorities. [38] The data does not include initial fracture morphology and classification, and therefore we cannot determine why, but only report that this association does exist.

Results from this study also found a difference in hospital LOS following operative treatment of tibial plateau fractures between the four study cohorts, with racial minority patients having an average hospital course 2 days longer than their Caucasian counterparts. This trend has also been demonstrated in two reports after total hip replacement, where authors found that non-whites had significantly higher risk of a longer LOS after adjusting for comorbidities. [30,31]

Weaver et al. also found that Caucasians were less likely to have longer LOS after a total knee replacement, using a stepwise regression analysis to control for confounding variables. [31] While some have speculated that open fractures and external fixator use could contribute to longer stays due to surgical staging [11], we found that race remained an independent predictor of LOS after controlling for these factors in our multiple regression model. It can be hypothesized that post-hospitalization placement could result in varying hospital courses, as non-whites may be less likely to be referred to rehabilitation facilities, therefore staying longer in the acute hospital for discharge planning. While we cannot accurately determine why minority patients are less likely to be discharged to inpatient medical facilities, socioeconomic factors or insurance issues might play a role, especially as estimated median family income also continued to be an independent predictor of increased LOS. Our report supports both of these hypotheses, as Caucasians were less likely to have open fractures and be discharged home after fixation of their tibial plateau fracture, while African Americans had lower rates of private insurance and were more likely to be discharged home.

There are several limitations that should be addressed when analyzing this study. A retrospective registry by nature presents a large potential for the data to be confounded by underlying biases. Still, this registry has the ability to establish possible causation relationships. For example, while Caucasians were more likely to have postoperative delirium and require transfusions, they are also an older population, perhaps resulting in increased rates of complications. While these links cannot be proven directly, the large SPARCS database has the potential to elucidate these patterns. Another limitation is that this registry attempted to group individuals from diverse backgrounds into distinct categories based on race. For example, the designation of Hispanic is a broad category of 400 million people of various countries of origin,

cultural values, and socioeconomic class.[32] Therefore, in attempt to group these patients into a single stratum, the results might under or over represent a true disparity. Methods for collecting classifications of race are also filled with flaws and confounding factors. Still, while definitions unfortunately lack consistency, race can be used as classification scheme as they are self-reported findings. Our study was also limited by the fact that we were unable to view X-ray reports. Thus, we could not determine the severity of fractures for our patient population. Finally, our study was limited to data from one state, limiting the generalizability of the results. For example, individuals from New York may have different cost of living and access to healthcare from those who live in California, and therefore, injury characteristics and socioeconomic trends could vary significantly.

Conclusion:

In conclusion, this study demonstrates no variation by race in the rate of many 30-day hospital complications such as in hospital mortality, and readmission rates following tibial plateau fracture treatment. This lack of association continued in the logistic regression model, even when estimated median family income was controlled. Independent risk factors for 30-day readmission were: age, LOS, open fractures, external fixator use, insurance type and comorbidities. Although African-Americans were found to have higher rates of open fractures and external fixation use, this population was not found to be associated with worse short term outcomes. **However, racial minority patients were treated non-operatively more frequently and had longer lengths of hospital stay as compared to Caucasians. While socio-economic and cultural factors can contribute to racial disparities throughout medicine, this report demonstrates that with respect to treatment of these injuries, the effect of racial and ethnic**

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371 Tables Legend:

372 Table 1: Baseline and Injury Characteristics Based on Race/Ethnicity

373 Table 2: In-Hospital Outcomes Based on Race/Ethnicity

374 Table 3: Summary of the Multiple Regression Analysis

375 Table 4: 30-Day Readmission Rates Based on Race/Ethnicity

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Table 1: Baseline and Injury Characteristics Based on Race/Ethnicity

Race	Caucasian	African American	Hispanic	Other	p value
# of patients	8228 (60.9%)	2413 (17.9%)	1297 (9.6%)	1580 (11.7%)	
Patient Characteristics					
Age	51.56	40.4	43.5	46.5	<0.001
Female	4246 (51.6%)	859 (35.6%)	501 (38.6%)	660 (41.8%)	<0.001
Private Insurance	5143 (62.5%)	1269 (52.6%)	648 (50.0%)	975 (61.7%)	<0.001
Medicaid	551 (6.7%)	765 (31.7%)	405 (31.2%)	329 (20.8%)	<0.001
Zip Code Estimated Median Family Income	\$85,223	\$56,972	\$61,698	\$70,474	<0.001
Comorbidities					
Elixhauser Comorbidity Scale of 3	1456 (17.7%)	338 (14.0%)	188 (14.5%)	185 (11.7%)	<0.001
CHF	239 (2.9%)	43 (1.8%)	26 (2.0%)	27 (1.7%)	<0.001
Depression	708 (8.6%)	75 (3.1%)	60 (4.6%)	54 (3.4%)	<0.001
AIDS	33 (0.4%)	84 (3.5%)	23 (1.8%)	13 (0.8%)	<0.001
Drug Abuse	189 (2.3%)	169 (7.0%)	66 (5.1%)	47 (3.0%)	<0.001
Psychiatric	58 (0.7%)	51 (2.1%)	14 (1.1%)	6 (0.4%)	<0.001
Obesity	469 (5.7%)	144 (6.0%)	74 (5.7%)	60 (3.8%)	0.03
Injury Characteristics					
Open Fracture	397 (4.7%)	186 (7.7%)	71 (5.5%)	111 (7.0%)	<0.001
Ex Fix	732 (8.9%)	224 (9.3%)	10.0%	204 (12.9%)	<0.001

CHF: Congestive Heart Failure; AIDS: Acquired Immune Deficiency Syndrome; Ex Fix: External Fixation

Table 2: In-Hospital Outcomes Based on Race/Ethnicity

Race	Caucasian	African American	Hispanic	Other	p value
In Hospital Outcomes					
Mean Length of Stay in Days	6.4 \pm 7.4	8.4 \pm 9.8	8.3 \pm 9.7	8.3 \pm 8.3	<0.001
Inflation adjusted total charges	\$34,123	\$35,535	\$43,487	\$40,854	<0.001
Non-operatively treated	675 (8.2%)	234 (9.7%)	123 (9.5%)	104 (6.6%)	0.01
Discharge to Facility	2707 (32.9%)	623 (25.8%)	342 (26.4%)	465 (29.4%)	<0.001
In hospital mortality	16 (0.2%)	2 (0.1%)	1 (0.1%)	2 (0.1%)	0.39
Infection	58 (0.7%)	24 (1.0%)	10 (0.8%)	19 (1.2%)	0.37
PE	58 (0.7%)	17 (0.7%)	8 (0.6%)	11 (0.7%)	0.99
Hematoma/Seroma	25 (0.3%)	10 (0.4%)	5 (0.4%)	11 (0.7%)	0.06
Wound Dehiscence	8 (0.1%)	2 (0.1%)	4 (0.3%)	5 (0.3%)	0.20
Transfusion	872 (10.6%)	205 (8.5%)	93 (7.2%)	153 (9.7%)	<0.001
Post Op Delirium	165 (2.0%)	31 (1.3%)	19 (1.5%)	14 (0.9%)	0.01
≥ 2 Post Op Complications	625 (7.6%)	125 (5.2%)	77 (5.9%)	111 (7.0%)	<0.001
Fasciotomy	436 (5.3%)	80 (3.3%)	69 (5.3%)	85 (5.4%)	<0.001

PE: Pulmonary Embolism

Summary of Multiple Regression Analysis

VARIABLE	ODDS RATIO	95% CI FOR ODDS RATIO	P VALUE
AGE	0.011	0.003-0.02	0.01
ESTIMATED MEDIAN FAMILY INCOME	-0.218	-0.345-(-0.09)	0.001
AFRICAN AMERICAN	1.924	1.545-2.303	0.001
HISPANIC	1.903	1.438-2.367	0.001
OTHER MINORITIES	1.849	1.431-2.268	0.001
OPEN FRACTURE	4.682	4.101-5.263	0.001
USE OF EX-FIX	7.083	6.632-7.533	0.001
ELIXHAUSER COMORBIDITY SCALE	0.976	0.842-1.110	0.001
DISCHARGE HOME	-2.803	-3.134-(-2.473)	0.001

Table 4: 30-Day Readmission Rates Based on Race/Ethnicity

Race	Caucasian	African American	Hispanic	Other	p value
Readmissions					
30 Day Readmission	741 (9.0%)	212 (8.8%)	101 (7.7%)	125 (7.9%)	0.24
Medical Complications	276 (37.2%)	78 (36.9%)	38 (38.2%)	56 (44.4%)	0.50
DVT/PE	52 (7.0%)	5 (2.4%)	4 (4.0%)	9 (7.1%)	0.04
Antibiotics	71 (9.6%)	37 (17.4%)	9 (8.9%)	16 (12.7%)	0.03
Debridement	104 (14.0%)	35 (16.4%)	21 (20.9%)	21 (16.7%)	0.29
Transfusion	44 (5.9%)	4 (1.9%)	6 (6.0%)	4 (3.1%)	0.05
Revision	65 (8.8%)	14 (6.5%)	3 (3.0%)	11 (8.7%)	0.19

DVT/PE: Deep Vein Thrombosis/Pulmonary Embolism