Trends in Orthopedic Fracture and Injury Severity: A Level I Trauma Center Experience

NEIL TARABADKAR, MD; TIMOTHY ALTON, MD; JACOB GORBATY, BS; SEAN NORK, MD; LISA TAITMAN, MD; CONOR KLEWENO, MD

abstract

The purpose of this study was to define the trends in fracture complexity and overall injury severity of orthopedic trauma patients at a level I trauma center. A retrospective review of a prospectively collected trauma database was performed to determine the Injury Severity Score (ISS) and AO/OTA classification of the most common fractures among all patients presenting from 1995 to 1999 and from 2008 to 2012. Inclusion criteria were lower extremity fractures of the femur and tibia and pelvic fractures within the years of interest. Exclusion criteria were age younger than 18 years, pathologic fractures, and insufficient medical records to determine ISS or AO/OTA classification. The total number of fractures increased from 4869 between 1995 and 1999 to 5902 between 2008 and 2012. There was an increase in the percentage of lower extremity periarticular fractures (20.7% to 23.4%, P<.001) and the percentage of pelvic and acetabular fractures (32.7% to 39.9%, P<.001) and a decrease in the percentage of lower extremity extra-articular fractures (46.6% to 36.7%, P<.001). The ratios of tibial pilon and plateau fractures relative to extra-articular tibial fractures increased from 0.29 to 0.60 (P<.001) and from 0.49 to 0.81 (P<.001), respectively. The average ISS had increased from 2008 to 2012 compared with from 1995 to 1999 (19.2 vs 15.1, P<.001). The complexity of certain lower extremity fractures and the severity of injury of patients treated at this referral institution are high and continue to increase. As US health care economics continue to change, with provider and hospital reimbursements shifting toward a patient outcomes basis with potential penalties for complications and readmissions, hospitals and providers must recognize these trends. Trauma centers must continue to measure the complexity of fracture care provided to properly risk-stratify their patient population. [Orthopedics. 2018; 41(2):e211-e216.]

The cost burden of trauma care has been well documented in the literature, with trauma ranking as one of the most expensive medical situations in the United States because of the combined expenses of its immediate care and long-term follow-up.1 Orthopedic trauma is no exception, and the incidence and complexity of lower extremity fractures as well as the overall severity of polytrauma both appear to be on the rise. With the establishment of Advanced Trauma Life Support, advances in car safety design, and resuscitation efforts, polytraumatized patients often survive their injuries and are transferred to high-acuity trauma centers for definitive management. Therefore, patients arriving at level I trauma centers are presenting with injury patterns that would have proven fatal in the past.2-4

These high-energy injury mechanisms lead to multiply injured patients with associated pelvic fractures and articular fractures of the tibial plateau and pilon.5-7 According to the most frequently used classification system, these are AO/OTA B and C type fractures.8

The authors are from the Department of Orthopaedic Surgery, Harborview Medical Center, University of Washington, Seattle, Washington.

The authors have no relevant financial relationships to disclose.

Correspondence should be addressed to: Conor Kleweno, MD, Department of Orthopaedic Surgery, Harborview Medical Center, University of Washington, 325 9th Ave, Box 359796, Seattle, WA 98104 (ckleweno@uw.edu).

Received: March 3, 2017; Accepted: November 30, 2017.
doi: 10.3928/01477447-20180103-01
Many of these fractures are managed in a staged fashion, with initial external fixation and soft tissue rest followed by definitive surgical intervention. This requires multiple inpatient hospital stays and is expensive. For more severely injured patients, trauma centers often first implement provisional “damage control orthopedics.”

In addition, high-energy periarticular and pelvic fractures are associated with many nonorthopedic injuries, as reflected by the Injury Severity Score (ISS). The ISS, first described in 1974, is an anatomic scoring system that gives an overall score for polytraumatized patients. Each injury is given an Abbreviated Injury Scale score and is grouped into a choice of 6 anatomic regions. The 3 body regions with the highest Abbreviated Injury Scale score and is grouped into a choice of 6 anatomic regions. The 3 body regions with the highest Abbreviated Injury Scale scores have their scores squared and added together to produce the ISS. A high ISS is often seen in polytraumatized patients with associated injuries such as damaged soft tissues, open injuries, and increased risk of infection, all of which may require extended hospital stays and repeat operations. Higher ISSs indicate higher morbidity and mortality rates and increased risk of perioperative complications.

The authors hypothesized that the orthopedic patients presenting to their level I trauma center have increasingly complex lower extremity periarticular and pelvic fractures and higher ISSs compared with a decade ago.

**MATERIALS AND METHODS**

This retrospective study received institutional review board approval. The prospectively collected orthopedic trauma database of the authors’ institution was queried to identify all patients sustaining lower extremity fractures of the femur, tibia, and pelvis during two 5-year time periods: between January 1995 and December 1999 and between January 2008 and December 2012. These time periods were chosen as a representation of the changing complexity of fractures presenting to the institution. No demographic data were obtained from the database. Fractures are entered into the database and coded according to the AO/OTA fracture classification system by orthopedic trauma fellows trained in this classification system.

Lower extremity fractures of the femur, tibia, and pelvis within the years of interest were included. Exclusion criteria were age younger than 18 years, pathologic fractures, and insufficient medical records to determine ISS or AO/OTA classification.

Using the AO/OTA classification system, the authors identified all 31 A-C (proximal femur), 32 A-C (femoral shaft), 33 A-C (distal femur), 41 A-C (proximal tibia), 42 A-C (tibial shaft), 43 A-C (distal tibia), 61 A-C (pelvic ring injuries), and 62 A-C (acetabular fractures). They then calculated the number of A, B, and C type fractures for each bone and each bone level (proximal, diaphysis, distal) that presented during the time periods to obtain the differences in fracture numbers. In addition, they compared all A type fractures vs B and C type fractures, regardless of the bone affected (ie, proximal tibia vs distal femur).

The ISS is also entered into this database. The ISS was recorded for each fracture included in this study. Patients from each time cohort were grouped into ISS “categories,” which were based on 10-point increments, to evaluate whether ISSs were increasing.

**RESULTS**

There were 2 cohorts of patients: group 1 (January 1995 to December 1999) and group 2 (January 2008 to December 2012). The total number of fractures increased from 4869 to 5902 between the 2 time periods (Table). There was an increase in the percentage of lower extremity periarticular fractures (20.7% to 23.4%, *P*<.001) and the percentage of pelvic and acetabular fractures (32.7% to 39.9%, *P*<.001) and a decrease in the percentage of lower extremity extra-articular fractures (46.6% to 36.7%, *P*<.001).

Based on the AO/OTA classification, the overall complexity of fractures significantly increased between the 2 time periods (A type fractures compared with B and C type fractures; ie, extra-articular; *P*=.041). Specifically, the ratio of intra-articular tibial pilon fractures relative to extra-articular tibial fractures increased from 0.29 to 0.60 (*P*<.001).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractures, Total No.</td>
<td>4869</td>
<td>5902</td>
<td>N/A</td>
</tr>
<tr>
<td>Lower extremity periarticular fractures</td>
<td>20.7%</td>
<td>23.4%</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Pelvic and acetabular fractures</td>
<td>32.7%</td>
<td>39.9%</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Lower extremity extra-articular fractures</td>
<td>46.6%</td>
<td>36.7%</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Intra-articular pilon fractures to extra-articular</td>
<td>29.5%</td>
<td>60.7%</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>tibial fractures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intra-articular tibial plateau fractures to extra-</td>
<td>49.2%</td>
<td>81.7%</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>articular tibial fractures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intra-articular distal femur fractures to femoral</td>
<td>26.1%</td>
<td>22.4%</td>
<td>.148</td>
</tr>
<tr>
<td>shaft fractures</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviation: N/A, not applicable. *Statistically significant.
The ratio of intra-articular tibial plateau fractures relative to extra-articular tibial fractures increased from 0.49 to 0.81 ($P<.001$). Thus, for each extra-articular tibial fracture, there were 1.4 intra-articular tibial fractures treated in the later cohort compared with 0.79 intra-articular tibial fractures treated in the earlier cohort.

The ratio of intra-articular distal femur fractures to femoral shaft fractures remained unchanged (0.26 to 0.22, $P=148$). However, the proportion of femoral shaft fractures decreased from 17.1% to 13.2% ($P<.001$) of the total fractures, and extra-articular tibial fractures decreased from 19.4% to 13.9% ($P<.001$) between the 2 time periods.

Acetabular and unstable pelvic fractures significantly increased from 26.9% to 34.4% of the total fractures ($P<.001$) between the 2 time periods.

The average ISS from 2008 to 2012 had increased compared with that from 1995 to 1999 (19.2 vs 15.1), being significantly greater for each 10-point stratification of the ISS data (Pearson chi-square, $P<.001$) (Figure).

**DISCUSSION**

This study indicates that there has been a significant increase in the number of higher-energy periarticular injuries treated at the authors’ institution, as reflected by the increase in B and C type fractures compared with A type fractures. Specifically, the ratios of pilon and tibial plateau fractures approximately doubled relative to the more simple extra-articular tibial fractures. The ISS was also found to have significantly increased. Compared with previous years at the authors’ institution, the fractures being treated are more severe and complicated, and the patients with these injuries have more severe polytrauma.

High-energy partial and complete articular fractures such as distal femur, tibial plateau, and pilon, especially type B and C fractures, have been shown to have poor outcomes for reasons such as articular surface comminution, extensive soft tissue damage, and impaction. These injuries are often associated with other injuries; have high rates of infection, given the extensive amount of damage to the soft tissue envelope; and have higher risk of posttraumatic arthrosis, given the intra-articular damage. Rademakers et al examined 67 patients with intra-articular distal femur fractures and found a 10% complication rate. They attributed this to the extensile exposure, damaged soft tissue envelope, and long operating time. Korkmaz et al showed that high-energy pilon fractures with extensive articular comminution had worse outcomes than lower-energy injuries including decreased range of motion. Pilon fractures with extensive articular comminution had worse outcomes than lower-energy injuries including decreased range of motion, whereas Williams et al showed that the outcomes after pilon fractures were most influenced by their pre-fracture comorbidities. As the energy increases for these fractures, the outcomes become poorer. Berkson and Virkus in their review of tibial plateau fractures, pointed out that infection rates are high in type B and C plateau fractures. They cited the soft tissue trauma and devascularization at the time of injury in addition to the soft tissue dissections at the time of definitive fixation as reasons for these increased infection rates. With the use of the now abandoned single anterior incision with near complete soft tissue stripping (the so-called “dead bone sandwich”), infection rates of bicondylar tibial plateau fractures treated with bicondylar fixation techniques were as high as 80% and often led to amputations. Although these rates have decreased as surgical technique and implant design have improved, they remain high. Ruffolo et al cited a 23.6% deep infection rate in their review of 138 bicondylar tibial plateau fractures. Moreover, patient outcomes continue to be suboptimal. In a review by Ahearn et al, 55 tibial plateau fractures were examined, with completed outcome measures obtained for 36 patients. The mean Western Ontario and McMaster Universities Osteoarthritis Index score was 70, the Short Form-36 physical component score was...
40, and the Short Form-36 mental component score was 47. These are low outcome scores despite evidence of excellent radiographic union.

This is in stark contrast to low-energy injuries of the distal tibia such as Weber B ankle fractures or isolated medial malleolar fractures. These injuries are not associated with the same perioperative infections or postoperative arthritis and pain commonly seen with pilon fractures. The amount of risk assumed by the surgeon operating on a low-energy ankle fracture is much less than that assumed by the surgeon operating on a high-energy pilon fracture. Surgeons who routinely treat complicated periarticular injuries will have longer operative times, and their patients will have a longer hospital stay and an increased rate of postoperative complications (e.g., infection, arthritis, revision surgery).

Acetabular and pelvic ring injuries are unique because they have historically been associated with high mortality rates. Open pelvic ring injuries have a high incidence of hemorrhage, abdominal trauma, and other associated injuries. Although these injuries were often fatal in the past, new resuscitative measures and specialized trauma-centered care are decreasing mortality. As a result, there are an increasing number of complex pelvic injuries requiring treatment. Consistent with this, the authors saw a significant increase in these injuries presenting to their trauma center. Morshed et al examined the outcomes of 829 pelvic and acetabular injuries. They found that patients with unstable pelvic ring injuries, the most severe acetabular injuries (OTA 62-B and 62-C), and combined pelvic and acetabular injuries had lower mortality rates at 90 days and at 1 year when treated at level I trauma centers.

Health care economics and health care policy are changing in the United States. There has been a large push across all of medicine to define appropriate care based on outcomes, often penalizing providers for hospital readmissions and “poor” outcomes. These poor outcomes remain inadequately defined and vary widely between, and even within, medical specialties. Although some currently used quality metrics such as readmissions, complications, and deaths are risk adjusted for factors such as ISS, sex, and age, they do not take into account factors such as fracture complexity, low socioeconomic status, and poor family support, which are common among patients cared for at urban level I trauma centers. Andrawis et al highlighted many of the factors, such as poor multi-institutional patient registries and no consensus on quality measures and indications for treatment, associated with difficulties in measuring outcomes in orthopedics and in health care in general.

There has been a push toward using outcome measures to standardize reimbursement and evaluate successful treatment. Most of this literature has involved total hip and knee arthroplasty and joint registries. Outcome metrics that are to be linked to physician and hospital reimbursement should vary, similar to the way patient injury severity and comorbidities vary. Patients cared for at level I tertiary referral centers are, in general, not the same cohort of patients cared for at local community hospitals and have different expected postoperative complication risk profiles and functional outcomes. Otherwise, a system is created in which there is no financial motivation to care for complicated injuries. In fact, providers and hospitals would be penalized for taking on the risk of caring for patients with these complicated injuries and incentivized for taking care of simple injuries for which patients will have reliably better outcomes with fewer complications.

It is also important to differentiate between various subspecialties in orthopedics and appreciate that outcome measures used for total joint arthroplasty cannot be used for orthopedic trauma. A total knee arthroplasty will have a different outcome for an otherwise healthy individual than for a patient with a type IIIB open tibia injury from high-energy trauma. There has been an administrative and social push for hospital reimbursement structures to assign “values” based on patient outcomes, not the volume of patients treated. With US health care economics changing to reimbursements based on patient outcomes, it is important to acknowledge that patients cared for at level I trauma centers are presenting with increasingly complex injury patterns and higher ISSs, predisposing them to an increased risk of complications and negative outcomes. Outcome measures considering overall patient wellness, presenting injuries, and the predisposition for complications based on these factors must be formulated for individual subspecialties.

The ISS has been shown to be a good predictor of patient outcomes. Many studies have found that the higher the ISS, the poorer the outcome for the patient. The ISS, and other morbidity and mortality score predictors such as the Case Mix Index, should continue to be incorporated into systems that measure the outcomes of the care of trauma patients.

This was a retrospective study with inherent limitations. The data were from a trauma database with a large referral area. However, the authors did not present outcomes or complication rates for these patients. In addition, no demographic data were obtained for this study. Therefore, the results may be partly related to changes in demographics in the authors’ area. Also, only patients who undergo surgery are entered in the database, so fractures treated without surgery were not captured in this cohort.

Historically, ISS has been the industry standard for accurate measurement of injury severity, and it is the value calculated and reported in the authors’ database. Recently, other scoring systems, such as the New Injury Severity Score and the Trauma Mortality Prediction Model, have proven to be more accurate representations of both severity and mortality prediction.
The use of newer severity scoring systems may provide a more accurate clinical picture of overall patient morbidity.

In addition, the authors did not have cost data for the surgical intervention, hospitalization, or clinic follow-up.

Finally, these data may not be applicable across all hospital settings, given the unique nature of tertiary referral centers.

**Conclusion**

Health care economics continue to change in the United States, with provider and hospital reimbursements shifting toward a system based on patient outcomes with potential penalties for complications and readmissions. In this evolving reimbursement environment, accurate determination of the severity of fractures treated and appropriate patient risk stratification based on anticipated outcomes and complications are increasingly important. These data demonstrate that the complexity of certain lower extremity fractures and the severity of injury of patients treated at this referral institution are high and continue to increase. In the setting of increasing injury severity, the authors observed proportionally fewer diaphyseal fractures and increased periarticular, acetabular, and unstable pelvic fractures. This information should be considered in risk-stratification analyses as new reimbursement algorithms are developed.

**References**


