An assessment of the incidence, variations in care and clinical outcomes of open tibial fractures in England

Hasan Mohammad and Xavier L Griffin

Hasan Mohammad studied at the University of Oxford and is an NIHR academic clinical lecturer at Barts Bone and Joint Health in London. He is an ST6 on the Percival Pott Rotation. His areas of interest include big data, implant engineering and clinical studies to help optimise patient outcomes following surgery. Hasan has been awarded various academic distinctions, funding and scholarships for his work.

Professor Xavier Griffin is Professor of T&O Surgery and Centre Lead for Bone and Joint Health at Queen Mary University of London and Barts Health, and the President of the Orthopaedic Trauma Society (OTS). Driven by a commitment to improving patient care, his research focuses on the clinical and cost effectiveness of new and existing treatments to advance bone and joint health. He has secured more than £45 million in research funding, alongside over 120 peer-reviewed publications and his work has been cited by NICE. He is passionate about developing innovative methodologies that harness the power of routinely collected data while combining this with the rigour of randomisation.

What does this study add?

- The overall incidence of open tibial fractures has more than doubled in recent years.
- There is variation in care of open tibial fractures, with patients presenting out of hours and just prior to the weekend being less likely to have timely surgical intervention.
- Multidisciplinary guidelines are associated with improved clinical outcomes for open tibial fractures.

Introduction

Open fractures are devastating injuries associated with considerable mortality and morbidity, including a 50% reduction in quality of life, which is even greater burden than that of a stroke[1]. Therefore, it is crucial that surgeons have access to accurate incidence estimates of these injuries to prepare accordingly. Open tibial fractures are a particular challenge as they are characterised by an at-risk soft tissue envelope with high contamination risk. They are associated with high rates of infection, non-union and amputation[2]. The average direct care cost of an open lower limb fracture in the first year alone equates to £14,000[3] and the projected lifetime cost of an open tibial fracture is up to £500,000, if the affected limb requires reconstruction or amputation[2].

Important changes have occurred in recent years that may affect open fracture outcomes. First, major trauma services were organised into Regional Trauma Networks (RTNs) based on specialist Major Trauma Centres (MTCs) in London in 2010 and later across England from 2012[4]. Second, clear multidisciplinary guidelines (NG37[5] and BOASt – Open Fractures[6]) were published in the UK in 2016 to standardise the management of open fractures. These guidelines required patients with open fractures be transferred directly from the point of injury to a specialist orthoplastics hospital which in most cases was an MTC. The impact of this policy introduction and major reorganisation on patient outcomes is unknown.

Methods

The Trauma Audit and Research Network (TARN) registry has collected prospective data on severely injured patients since 1989[7]. It included patients of all ages who sustained injuries resulting in hospital admission longer than 72 hours, critical care admission, transfer to a tertiary/specialist centre, and/or death within 30 days. Isolated femoral neck and pubic rami fracture in patients aged over 65 years and simple isolated injuries are excluded. TARN collected data detailing demographics, injury type and mechanism, physiological

parameters, investigations, treatments and outcomes. TARN case capture for eligible patients is in excess of 90%[7].

The HES Admitted Patient Care (HES-APC) dataset is managed by NHS England and captures data on all admissions to NHS hospitals in England[8]. Around 98-99% of hospital activity in England is funded by the NHS. The dataset includes demographic characteristics, deprivation indices, ICD diagnosis codes, and OPCS-4 procedure codes. HES can also be used to track patients longitudinally over multiple hospital admissions, which can facilitate identification of post-operative complications. We obtained approvals to link the TARN dataset to the HES-APC dataset using patient identifiers to create a unique bespoke dataset designed to answer four key questions:

1. What is the incidence of open fractures and open tibial fractures?

38,347 open fractures were recorded in the TARN linked dataset between 1st January 2008 and 31st December 2019. 90% of patients presented with isolated injuries with blunt trauma occurring in 95% of cases. Most common mechanisms of injury were vehicle incidents/collisions (43%) and falls of under two metres (36%). 60% of all open fractures occurred in male patients (n=23,123). The overall incidence was 5.91 per 100,000 person years and rose during the study period. In 2008, the incidence was 2.50 per 100,000 person years rising in 2019 to 7.03 per 100,000 person years (Figure 1). Male patients demonstrated a bimodal distribution by age with peak incidences of 11.5 per 100,000 person years in 20 to 29-year-olds and 10.7 per 100,000 person years in over 90-year-olds. Female patient's incidence rose with age peaking in the over 90-year-olds with 32.1 per 100,000 person years. 46% of patients with open fractures had one operation and 19% had two operations.

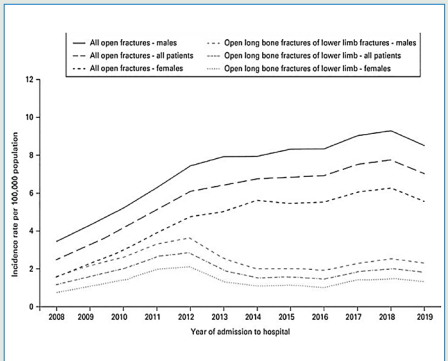

Figure 1: Incidence of patients, organised by sex, with an open fracture and severe open fracture of the tibia who were admitted to a hospital in England from 2008 to 2019, as recorded in the Trauma Audit and Research Network[9]. [*Bone Joint J.* 2022;104(6):736-46.

From the 38,347 fractures, 12,170 were open fractures of the tibia. The overall incidence during the study period was 1.87 per 100,000 person years. Similar patterns were found of rising incidence during the study period, with rates of 2.50 per 100,000 in 2008 and 7.03 per 100,000 in 2019. A similar bimodal distribution was seen in males age and for female's incidence increased with age. 64% of open tibial fractures occurred in men. 34% of patients were treated with one operation and 22% with two operations. The most performed operations for open tibial fractures are summarised in Table 1.

Operation	Operation Number (%)
Skin debridement	6,560 (54%)
Internal fixation (other) and debridement	3,757 (31%)
Internal fixation (nail) and debridement	2,659 (22%)
Internal fixation (plate) and debridement	1,777 (15%)
External fixation	1,957 (16%)

Table 1: Most commonly performed operations for open tibia fractures[10]. [Adapted from *Bone & Joint Open*. 2022;3(12):941-52.]

2. Does the standard of care vary with time and place of presentation of people with open tibial fractures?

A subgroup of 8,258 open tibial fractures were included for these analyses. The effect of the type of hospital presentation and the time of presentation on surgical targets debridement within 12 hours and soft tissue coverage within 72 hours were studied.

During the study period 4,867 cases (58.9%) presented to an MTC and 3,391 (41.1%) to non-MTCs. The percentage of open tibial fractures managed in an MTC rose from 52.9% between 2012-2015 to 65.5% between 2016-2019. MTCs did not influence the chances of having debridement within 12 hours. The mean time to soft tissue coverage was 101 hours. Overall, 63% of patients achieved surgical coverage of the injury within 72 hours.

Subgroup analysis by MTC status found rates of 64% in MTCs compared with 61% in non-MTCs.

Patients presenting to hospital during day were more likely to have debridement within 12 hours compared to those at night (RR 1.11). Patients presenting at night were less likely to have debridement within 12 hours (RR 0.56). Soft tissue coverage within 72 hours was less likely on Thursdays (RR 0.88) and Fridays (RR 0.89).

3. Has NICE and BOASt guidance improved outcomes for people with open tibial fractures?

12,168 patients with severe open tibia fractures were available for analysis comparing outcomes before and after multi-disciplinary guidelines (NG375 and BOASt – Open Fractures[6]). The risk of mortality, venous thromboembolism (VTE), osteomyelitis, amputation and length of stay were compared before and after each intervention. Trends were studied using interrupted time series analysis (ITSA).

There were slight increases in the risk of the overall 30-day mortality (RR 1.38) and one-year mortality (RR 1.28). There was no significant change in the 30-day mortality trend, but -0.26% per quarter ([CI -0.41, -0.12], p=0.001) reduction in one-year mortality trend after the introduction of national guidelines which is equivalent to a drop of 1% per annum (pa) (Figure 2). >>

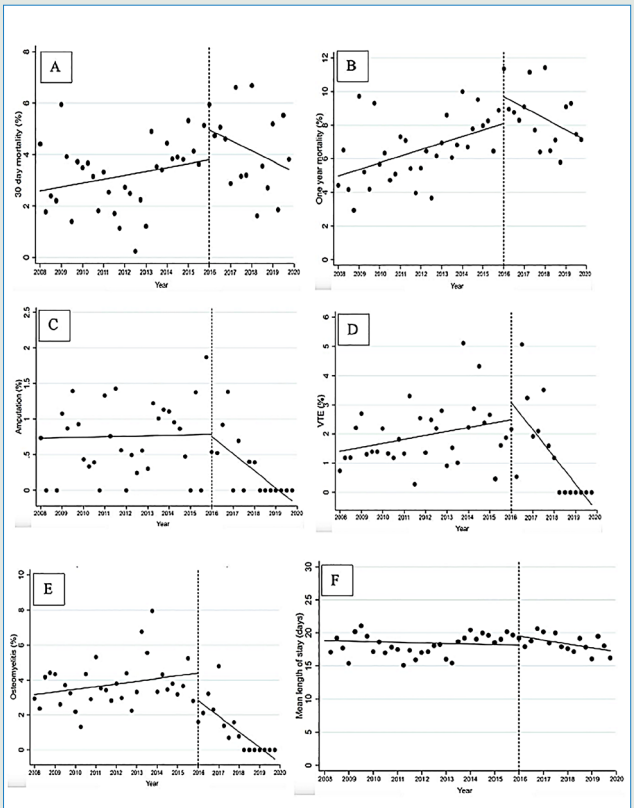

Figure 2: Interrupted time series of outcomes before and after national guideline introduction. (A) 30-day mortality, (B) one-year mortality, (C) amputation risk, (D) VTE risk, (E) osteomyelitis risk and (F) mean length of stay.

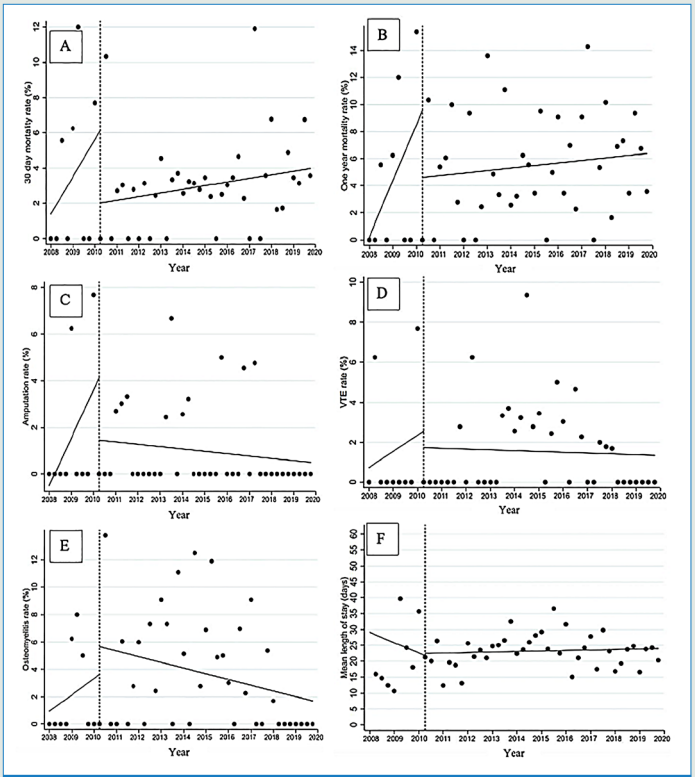

Figure 3: Interrupted time series of outcomes before and after reorganisation for London Hospitals. (A) 30-day mortality, (B) one-year mortality, (C) amputation risk, (D) VTE risk (E) osteomyelitis risk and (F) mean length of stay.

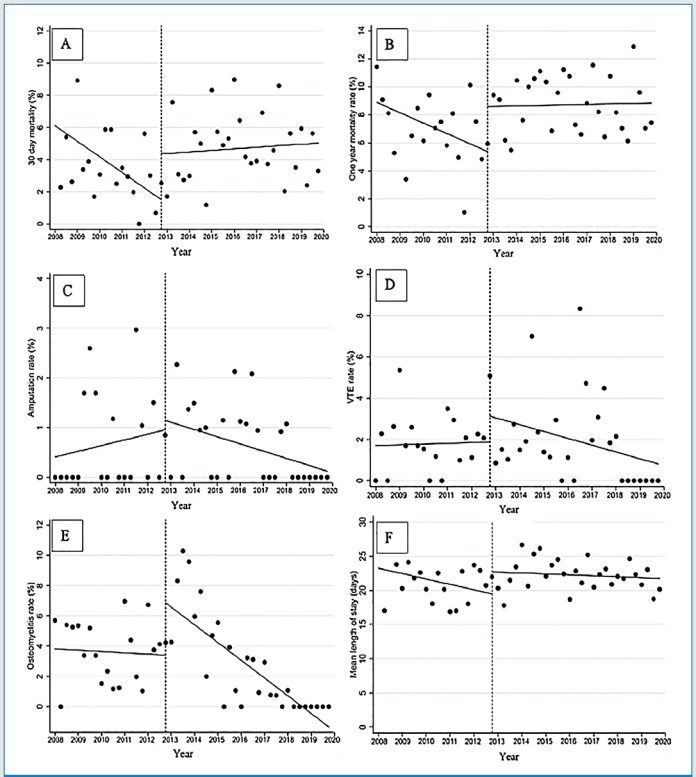

Figure 4: Interrupted time series of outcomes before and after reorganisation for non-London Hospitals. (A) 30-day mortality (B) one-year mortality (C) amputation risk (D) VTE risk (E) osteomyelitis risk and (F) mean length of stay.

There were reductions in the risk of VTE (RR 0.65), osteomyelitis (RR 0.28) and amputation (RR 0.38). Similarly, there was a significant reduction in the trend of local complications; amputation (-0.06% per quarter [-0.10, -0.20], -0.24% pa, p<0.001), osteomyelitis (-0.26% per quarter [-0.37, -0.15], 1.04% pa, p<0.001) and venous thromboembolism (-.0.27% per quarter [-0.41, -0.12], -1.08% pa, p=0.001) after the guideline introduction. There were no significant changes in the mean length of stay (Figure 2).

4. Have RTNs improved outcomes for people with open tibial fractures?

6,250 patients were treated in hospitals that subsequently became designated MTCs during the study period and were therefore included in this analysis. Analyses were divided into London and non-London hospitals.

There were no significant differences in the risk of the overall 30-day mortality after regionalisation and one-year mortality. There was no significant change in the 30-day mortality or one-year mortality trend for hospitals within and outside of London, (Figure 3 and 4). Mean length of stay was longer after regionalisation of major trauma services ([21.4 vs 22.4 days], p<0.001).

There were no significant differences in the risk of VTE, osteomyelitis and amputation after its introduction. There were no significant changes in trends after the introduction of RTNs in London hospitals for local surgical complications (Figure 3). There were no significant changes in trends after the introduction of RTNs in non-London hospitals for local surgical complications except for the osteomyelitis quarterly trend which significantly decreased by -0.27% per quarter ([CI -0.48, -0.06], p=0.01) equating to 1.08%pa (Figure 4).

Discussion

Our research has shown the incidence of open tibial fractures in England has more than doubled in recent years highlighting the increasing burden of these fractures. With age, the incidence rose for both males and females, such, that open tibial fractures are now most commonly a fragility fracture.

The introduction of clear multi-disciplinary guidelines (NG37[5] and BOASt – Open Fractures[6]) was associated with reversal of trends for rising mortality and surgical complications. The absolute risk of several complications (VTE, osteomyelitis and amputation) also fell nationally after its introduction.

Regionalisation of care into MTCs was not associated with any consistent advantage across the country. MTCs were not even associated with achieving timely debridement or soft tissue coverage. This is difficult to explain as we would have expected MTCs to improve outcomes by providing more specialised and timely care. This may be from transition periods after changeover dates, MTCs being overburdened, or just that the regionalisation analyses had much fewer numbers of patients.

There were variations in the care received for open tibial fractures depending on the time and day of presentation. Those presenting out of hours were less likely to have debridement performed within 12 hours and patients presenting on Thursdays and Friday were less likely to have soft tissue coverage within 72 hours, probably from lack of theatre capacity over the weekend. Services should be configured to provide equitable care irrespective of day or time of arrival.

This research has limitations. It is based on observational data and therefore cannot prove causality. In addition, the data was collected for the purposes of audit and not research. There was also a significant proportion of missing data which may confound our results. However, this dataset is the best currently available for studying the questions assessed.

Conclusion

This work shows that the incidence of open tibial fractures is increasing and now presents most commonly as a fragility fracture. Patients presenting out of hours and just prior to the weekend are less likely to achieve timely surgical care. New multidisciplinary guidelines are associated with improved clinical outcomes but regionalisation of care into MTCs has not improved outcomes. ■

Acknowledgment

JTO acknowledge the permission from *The Bone & Joint Journal* to reproduce content; full articles are available for free download at https://boneandjoint.org.uk/collection/tarn.

References

References can be found online at www.boa.ac.uk/JTO.