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Fasciotomy and rate of amputation after tibial fracture in adults: a population-based cohort study

Aurelia Bihari, PhD[a,b,*], J. Andrew McClure, MSc[c], Clayton Inculet, MD, FRCSC[a], Christopher Del Balso, MD, FRCSC[a], Christopher Vinden, MD, FRCSC[c], Emil Schemitsch, MD, PhD, FRCSC[a], David Sanders, MD, FRCSC[a], Abdel-Rahman Lawendy, MD, PhD, FRCSC[a,b]

Abstract

Objectives: Limb amputation is a possible outcome of acute compartment syndrome. We undertook this study to investigate the occurrence of fasciotomy and amputation in patients with tibial fractures in the Ontario adult population, aiming to evaluate variables that may be associated with each of these outcomes.

Design: Retrospective, population-based cohort study (April 1, 2003–March 31, 2016).

Setting: Canadian province of Ontario.

Participants: Patients with tibial fracture, aged 14 years and older.

Intervention(s): Fasciotomy after tibial fracture.

Main Outcome(s) and Measure(s): The primary outcomes were fasciotomy and amputation within 1 year of fasciotomy. Secondary outcomes included repeat surgery, new-onset renal failure, and mortality, all within 30 days of fasciotomy.

Results: We identified 76,299 patients with tibial fracture; the mean (SD) age was 47 (21) years. Fasciotomy was performed in 1303 patients (1.7%); of these, 76% were male and 24% female. Patients who were younger, male, or experienced polytrauma were significantly more likely to undergo fasciotomy. Limb amputation occurred in 4.3% of patients undergoing fasciotomy, as compared with 0.5% in those without fasciotomy; older age, male sex, presence of polytrauma, and fasciotomy were associated with an increased risk of amputation (age odds ratio [OR] of 1.03 [95% CI, 1.02–1.03], $P < 0.0001$; sex OR of 2.04 [95% CI, 1.63–2.55], $P < 0.0001$; polytrauma OR of 9.37 [95% CI, 7.64–11.50], $P < 0.0001$; fasciotomy OR of 4.35 [95% CI, 3.21–5.90], $P < 0.0001$), as well as repeat surgery within 30 days (sex OR of 1.54 [95% CI, 1.14–2.07], $P = 0.0053$; polytrauma OR of 4.24 [95% CI, 3.33–5.38], $P < 0.0001$).

Conclusions: Among tibial fracture patients, those who were male and who experienced polytrauma were at significantly higher risk of undergoing fasciotomy and subsequent amputation. Fasciotomy was also significantly associated with risk of amputation, a finding that is likely reflective of the severity of the initial injury.

Keywords: acute compartment syndrome, tibial fracture, fasciotomy, polytrauma, amputation

1. Introduction

Severe lower limb trauma is a potentially devastating injury that may result in death or profound disability of the patient. Tibial fractures are the most common type of injury, with etiology encompassing falls, sports injuries, direct blows, motor vehicle collisions, gunshots, and fragmentation injuries.[1] Risk of complications is high, particularly in the presence of an open fracture.[2,3] Severe extremity trauma often results in limb amputation, which can be attributable to a multitude of reasons: vascular injury, tissue necrosis, nonunion, irrecoverable crush injury, unsalvageable muscle injury and skin loss, extensive bone loss, osteomyelitis, articular damage to the foot, or wound infection.[4]

One of the possible complications of extremity trauma includes acute limb compartment syndrome (CS). CS is characterized by

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[a] *Division of Orthopaedic Surgery, Department of Surgery, London Health Sciences Centre, London, ON, Canada,* [b] *Centre for Critical Illness Research, Lawson Health Research Institute, London, ON, Canada,* [c] *ICES Western, London Health Sciences Centre, London, ON, Canada*

* *Corresponding author. Address: Rm A6-152, Victoria Research Labs, London Health Sciences Centre, Victoria Hospital, London, ON N6A 4G5, Canada. E-mail address: relka.bihari@lhsc.on.ca (A. Bihari).*

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an increase in pressure within a closed osseofascial compartment, resulting in muscle-threatening and ultimately limb-threatening ischemia.[5–7] Extensile fasciotomy, to fully decompress all the muscles in the involved compartments, remains the only effective therapy.[8] However, fasciotomy itself is not without complications (eg, infection, nerve, blood vessel and muscle damage, and wound healing issues),[9] and long-term sequelae are common.[10–12] These include altered sensation of wounds, skin sloughing, pruritus, chronic swelling, tethering of tendons and scars, recurrent ulceration, and muscle herniation,[13] and because of their persistent nature may severely limit patients' quality of life.[14]

CS often presents a diagnostic and therapeutic challenge in orthopaedic traumatology; its consequences may be severe for both the patient and the treating surgeon. The early diagnosis of CS is critical to its surgical management and avoidance of disability and litigation.[15,16] The most important determinant of poor outcome of CS after injury is delay in intervention: missed or late diagnosis results in serious and disabling complications, such as muscle infarction, muscle contracture, weakness and/or neurologic dysfunction,[17] infection,[18] amputation,[19] end-organ involvement,[19,20] and a significant increase in risk of mortality.[21] Impact and magnitude of injury in CS is time-dependent, with a surgical window of 4–8 hours before complete and irreversible damage is sustained. If there is a sufficient amount of muscle tissue involved, CS can lead to rhabdomyolysis, renal failure (secondary to myoglobinuria), and shock.[22,23] Limb amputation may not be life-saving at this point, depending on the degree of systemic insult.

Historic rates for amputation in acute lower extremity compartment syndrome approach 10% in the literature, while early amputation rates during initial admission in open tibia fractures have been reported around 2.2% for all comers.[24,25] To the authors' knowledge, there have been no direct studies assessing the rate of amputation for tibia fractures with and without acute compartment syndrome. Research on CS is challenging because of the lack of a 'true' diagnostic test, combined with the fact that the signs and symptoms of CS are often similar to those of the associated injury. Moreover, fasciotomy itself causes further loss of skin integrity, can expose the underlying fracture, and is associated with a high infection rate.[9] Therefore, the purpose of this study was to investigate the occurrence of fasciotomy within a large population-based cohort of patients with tibial fracture, as well as to assess potential risk factors/other injury or treatment-related variables associated with fasciotomy and subsequent amputation.

2. Materials and Methods

The study was exempt from research ethics board review, as per section 45 of the Ontario Personal Health Information Protection Act (PHIPA). The retrospective, population-based cohort study included all patients 14 or older, with a diagnosis of tibial fracture in the province of Ontario, Canada (population approximately 14 million), from April 1, 2003, to March 31, 2016.

2.1. Data Sources and Inclusion and Exclusion Criteria

Tibial fracture cases were detected from hospital, emergency department (ER), and physician billing records (these included combined injuries and multiply injured extremities, to maximize the number of patients captured within the database). For patients whose earliest evidence of tibial fracture was not from the ER, a 14-day lookback window was used to identify an associated ER visit. The ER visit date was defined as the date of fracture, and patients without an ER visit were excluded. We also excluded patients if they were non-Ontario residents, had undergone a previous fasciotomy, were younger than 14 years, or if they died within 14 days of fracture (ie, mortality most likely due to the initial (poly)trauma itself). The number of patients excluded at each step of the cohort build is presented in Figure 1. Incomplete or discordant inclusion criteria excluded patients from the study.

Residents of Ontario have universal access to health care through a provincial health insurance program, with insured services captured in administrative databases. Physician billing records were obtained from the Ontario Health Insurance Plan (OHIP) database; data related to hospital and same-day surgery services were obtained from the Canadian Institute for Health Information's (CIHI) Discharge Abstract Database and Same Day Surgery database. The Canadian Organ Replacement Register (CORR) was used to identify patients with renal failure. Additional patient characteristics were captured from the Registered Persons Database. These data sets were linked using unique encoded identifiers and analyzed at ICES (formerly the Institute for Clinical Evaluative Sciences, ICES) Western. Reporting of this study follows the RECORD statement (Table S1, http://links.lww.com/OTAI/A91).[26]

2.2. Variable Definitions

A combination of physician billing codes and hospital-based procedure codes was used to detect any evidence of fasciotomy within 14 days of fracture. The codes used to define fasciotomy, as well as all other study variables, are shown in Table S2, http://links.lww.com/OTAI/A92.

Patient baseline characteristics included age, sex, neighborhood income quintile (adjusted for household size and housing costs), rural residence, Charlson Comorbidity Index (CCI) score (based on hospitalizations during the previous 2 years), tibial fracture in the previous 10 years, history of renal failure, and number of hospital admissions in the previous year. A number of variables related to the index event were also captured: type and location of tibial fracture, hospital admission, teaching status of admitting hospital, length of hospital stay, diagnosis of crush injury, fiscal year of fracture, and polytrauma. Polytrauma was defined as a composite indicator representing ICU admission or resuscitation within 2 days of the index ER visit or consult with more than one type of surgical specialist (including orthopaedic, thoracic, general, vascular, plastic, and neurosurgery) within 7 days of the index ER visit. The billing premium for Injury Severity Scale (ISS) score >15 was also added to the definition of polytrauma[27,28] for patients accrued after its introduction on October 1, 2005.

The primary outcomes were fasciotomy and amputation within 1 year of fasciotomy, or within 1 year of injury for patients who did not undergo fasciotomy. Where laterality was available, amputation was only counted when it occurred on the same side as the fasciotomy. In rare circumstances where laterality was missing in our cohort buildup for either the fracture or the fasciotomy (this occurred in less than 5% of cases), we considered laterality to be on the same side, arguing that this was more likely than not. Secondary outcomes included repeat surgery, that is, complex tissue reconstruction/wound closure, new-onset renal failure, and mortality, all within 30 days of fasciotomy (30-day mortality did not include deaths that occurred within the first 14 days, to ensure that the patients captured in the database did

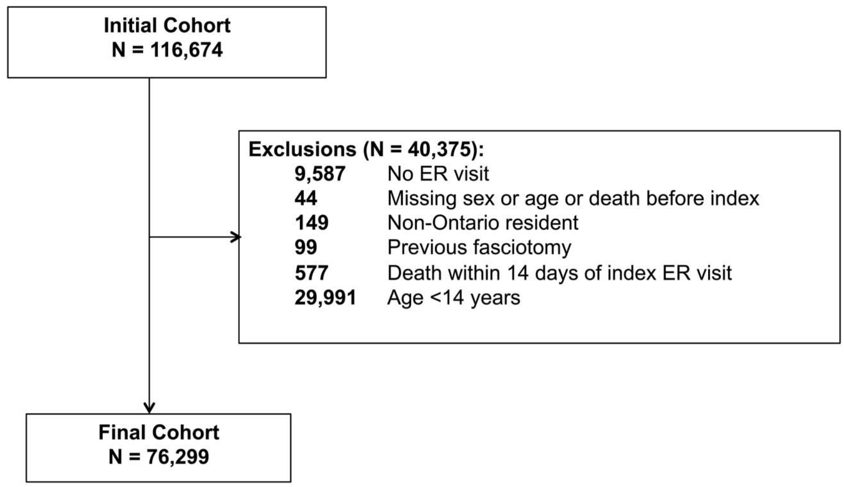

Figure 1. Study cohort buildup.

not die of the initial (poly)trauma itself). Repeat surgery captured a range of procedures associated with complex wounds, including flap coverage, debridement/excision of the fascia, and skin grafts, and did not include delayed primary closure of the wound (delayed primary closure was considered to be a standard of care for fasciotomy, not a repeat surgery).

2.3. Statistical Analysis

Baseline differences between patients who did or did not undergo fasciotomy after tibial fracture were evaluated using standardized differences (SDs). SDs greater than 0.10 can be interpreted as indicating a potentially meaningful between-group difference.[29] The Cochran–Armitage test for trend was used to assess changes in the proportion of patients who underwent fasciotomy over the study period. Logistic regression was used to explore associations between patient and fracture-related variables with fasciotomy, amputation, and repeat surgery after fasciotomy. The following covariates were considered for all models: patient age, sex, polytrauma, fasciotomy (only for the model investigating amputation), and fiscal year of the procedure. Fiscal year was ultimately excluded from models investigating amputation and repeat surgery because of the small number of events and a minimal association between each outcome and year of procedure. The linearity of continuous covariates was assessed using restricted cubic splines.[30] Patient age demonstrated a nonlinear association with fasciotomy and was, therefore, modeled as a categorical variable. For all analyses, reported *P*-values are from 2-tailed tests; a value of <0.05 was considered statistically significant. All analyses were performed using SAS EG version 7.1 (SAS Institute, Cary, NC).

3. Results

3.1. Patients

The study included 76,299 patients with tibial fractures (Fig. 1); 41,358 (53.8%) were male, and 34,941 (46.2%) were female (Table 1). The total number of tibial fracture patients requiring fasciotomy was 1303; of these, 989 patients (75.9%) were male and 314 (24.1%) were female (SD 0.48, $P < 0.0001$) (Table 1). The total number of patients who underwent fasciotomy in Ontario steadily decreased from 2003 until 2015 ($P < 0.0001$) (Fig. 2).

Hospital admission after tibial fracture within one day of the ER visit was required in 94.8% (n = 1235) of patients who underwent fasciotomy, as compared with 46.3% (n = 34,726) of those without fasciotomy ($P < 0.0001$) (Table 1). The average time from fracture to fasciotomy was 1.5 ± 2.2 days; 461 (35.4%) and 484 (37.1%) patients underwent fasciotomy on day 0 or day 1, respectively, while 134 patients (10.3%) underwent fasciotomy more than 4 days after fracture. The average length of stay for all admitted tibial fracture patients was 10.2 ± 17.7 days; for those undergoing fasciotomy, the average length of stay was 15.3 ± 17.7 days.

Of all tibial fracture patients, 9781 (12.8%) were polytrauma patients. Polytrauma was present in 593 patients (45.5%) who underwent fasciotomy as compared with 9188 patients (12.3%) without fasciotomy ($P < 0.0001$) (Table 1). Two thousand three hundred sixty-two patients (3.1%) with tibial fractures were admitted to ICU: of this population, 221 (17%) had a fasciotomy ($P < 0.0001$).

Of all tibial fractures, 63.4% (n = 48,366) were closed and 6.7% (n = 5100) were open fractures; these ratios were maintained in those who did not require fasciotomy (Table 2). In patients requiring fasciotomy, 69.6% (n = 907) were closed while 23.3% (n = 303) were open fractures ($P < 0.0001$) (Table 2). In terms of the location of tibial fractures, 30.8% were located in the proximal tibia, 21.6% in the distal tibia, and 17.8% in the tibial shaft; these ratios were reflective of all tibial fracture patients and those who did not require fasciotomy. In patients requiring fasciotomy, there was a significant shift toward fractures of the proximal tibia (n = 597, 45.8%), whereas 22.3% (n = 290) were of the distal tibia and 24.8% (n = 323) were of the tibial shaft ($P < 0.0001$) (Table 2). However, fracture type and location were not available for 29.9% of the overall cohort; this information was missing for a greater proportion of patients without fasciotomy (30.3% vs. 7.1%).

3.2. Predictors of Fasciotomy

Patient age was significantly associated with the need for fasciotomy in tibial fracture patients: as compared with those older than 66 years, those in the age groups of 26–41 and 42–53 years had odds ratios (OR) of 2.39 (95% CI, 1.91–2.98) and 2.42 (95% CI, 1.94–3.03), respectively, while ORs for those in the 14–25 and 54–66-year age groups were 1.81 (95% CI, 1.43–2.28) and 1.58

TABLE 1

Baseline Characteristics of Patients With/Without Fasciotomy Within 14 days of Tibial Fracture

Variable	Overall (n = 76,299)	No Fasciotomy (n = 74,996)	Fasciotomy (n = 1303)	Standardized Difference
Patient age (median, IQR)	47.0 (29.0–62.0)	47.0 (29.0–62.0)	41.0 (27.0–53.0)	0.30
Patient sex (male)	41,358 (54.2%)	40,369 (53.8%)	989 (75.9%)	0.48
Rural residence	10,613 (13.9%)	10,383 (13.8%)	230 (17.7%)	0.10
Income quintile				
Quintile 1	15,375 (20.2%)	15,094 (20.1%)	281 (21.6%)	0.04
Quintile 2	15,121 (19.8%)	14,882 (19.8%)	239 (18.3%)	0.04
Quintile 3	15,137 (19.8%)	14,885 (19.8%)	252 (19.3%)	0.01
Quintile 4	15,504 (20.3%)	15,224 (20.3%)	280 (21.5%)	0.03
Quintile 5	14,772 (19.4%)	14,533 (19.4%)	239 (18.3%)	0.03
Comorbidity index				
Charlson score = 0	70,092 (91.9%)	68,853 (91.8%)	1239 (95.1%)	0.13
Charlson score = 1	2475 (3.2%)	2448 (3.3%)	27 (2.1%)	0.07
Charlson score = 2	1849 (2.4%)	1830 (2.4%)	19 (1.5%)	0.07
Charlson score = 3+	1883 (2.5%)	1865 (2.5%)	18 (1.4%)	0.08
Previous hospitalizations				
Admissions = 0	69,657 (91.3%)	68,438 (91.3%)	1219 (93.6%)	0.09
Admissions = 1	4795 (6.3%)	4733 (6.3%)	62 (4.8%)	0.07
Admissions = 2	1122 (1.5%)	1114 (1.5%)	8 (0.6%)	0.09
Admissions = 3+	725 (1.0%)	711 (0.9%)	14 (1.1%)	0.01
Previous tibia fracture	680 (0.9%)	667 (0.9%)	13 (1.0%)	0.01
History of renal failure	NR	420 (0.6%)	≤5	<0.10
Polytrauma	9781 (12.8%)	9188 (12.3%)	593 (45.5%)	0.79
ISS > 15	2665 (3.5%)	2439 (3.3%)	226 (17.3%)	0.48
Crush injury	208 (0.3%)	166 (0.2%)	42 (3.2%)	0.23
Post-fracture admission	35,961 (47.1%)	34,726 (46.3%)	1235 (94.8%)	1.26
ICU admission	2362 (3.1%)	2141 (2.9%)	221 (17%)	0.49
Teaching institution*	12,784 (16.8%)	12,269 (16.4%)	515 (39.5%)	0.53

Missing data for 14 and 390 patients for rural residence and income quintile, respectively.
* Only includes patients with a post-fracture hospital admission.
IQR, interquartile range; ISS, injury severity score.

(95% CI, 1.24–2.01), respectively ($P < 0.0001$) (Table 3). Male sex was also a predictor of fasciotomy, with an OR of 2.09 (95% CI, 1.83–2.39) ($P < 0.0001$). Presence of polytrauma significantly increased the likelihood of the need for fasciotomy, with an OR of 5.79 (95% CI, 5.17–6.47) ($P < 0.0001$) (Table 3).

3.3. Primary Outcome: Limb Amputation

Of 1303 adults who underwent fasciotomy, amputation within one year of tibial fracture was required in 56 cases (4.3%), whereas it was required in 0.5% cases for those without fasciotomy, an OR of 9.34 (95% CI, 7.01–12.44). This association remained significant after adjustment in the logistic regression model, with OR of 4.35 (95% CI, 3.21–5.90). Older age, male sex, and presence of polytrauma were very significant predictors of amputation, with ORs of 1.03 (95% CI, 1.02–1.03) ($P < 0.001$), 2.04 (95% CI, 1.63–2.55) ($P < 0.0.001$), and 9.34 (95% CI, 7.64–11.50) ($P < 0.0001$), respectively (Table 4).

3.4. Secondary Outcomes: Repeat Surgery, New Onset of Renal Failure, and Mortality

Within the subgroup of fasciotomy patients, repeat surgery within 30 days was required in 526 cases (40.4%). There were

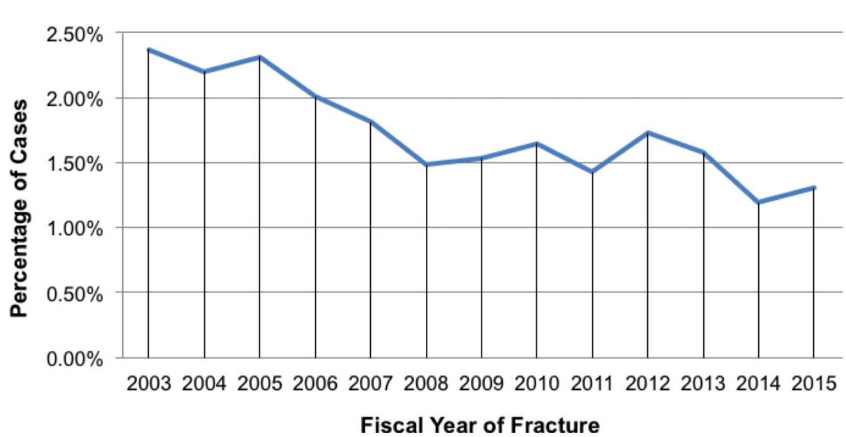

Figure 2. Percentage of cases of tibial fracture requiring fasciotomy in Ontario over the fiscal years of 2003–2015.

TABLE 2

Breakdown of Tibial Fractures by Fracture Type, Location and Management

Variable	Overall (n = 76,299)	No Fasciotomy (n = 74,996)	Fasciotomy (n = 1303)	Standardized Difference
Fracture type				
Closed	48,366 (63.4%)	47,459 (63.3%)	907 (69.6%)	0.13
Open	5100 (6.7%)	4797 (6.4%)	303 (23.3%)	0.49
Missing	22,833 (29.9%)	22,740 (30.3%)	93 (7.1%)	0.62
Fracture location				
Proximal	23,462 (30.8%)	22,865 (30.5%)	597 (45.8%)	0.32
Distal	16,443 (21.6%)	16,153 (21.5%)	290 (22.3%)	0.02
Shaft	13,561 (17.8%)	13,238 (17.7%)	323 (24.8%)	0.18
Missing	22,833 (29.9%)	22,740 (30.3%)	93 (7.1%)	0.62
Fracture service*				
Tibia fracture with or without fibula—no reduction, rigid immobilization	40,122 (52.6%)	39,829 (53.1%)	293 (22.5%)	0.67
Tibia fracture with or without fibula—closed reduction	15,133 (19.8%)	14,764 (19.7%)	369 (28.3%)	0.20
Tibia fracture with or without fibula—open reduction, shaft	15,652 (20.5%)	14,969 (20.0%)	683 (52.4%)	0.72
Medial or lateral tibial plateau reduction	8623 (11.3%)	8133 (10.8%)	490 (37.6%)	0.66
Ankle fracture with tibial plafond burst—closed reduction	610 (0.8%)	593 (0.8%)	17 (1.3%)	0.05
Ankle fracture with tibial plafond burst—open reduction	1866 (2.4%)	1808 (2.4%)	58 (4.5%)	0.11

* Not mutually exclusive (patients permitted to contribute to more than one category).

fewer than 5 cases (<0.5%) of new-onset renal failure and/or mortality within 30 days of tibial fracture.

Older age, male sex, and presence of polytrauma were significantly associated with the need for repeat surgery, with ORs of 0.83 (95% CI, 0.77–0.90) ($P < 0.0001$), 1.54 (95% CI, 1.14–2.07) ($P = 0.0053$), and 4.24 (95% CI, 3.33–5.38) ($P < 0.0001$), respectively (Table 4).

4. Discussion

Severe lower extremity trauma has a high incidence of complications and will often result in limb amputation. Amputation can be attributable to a multitude of reasons (vascular injury, tissue necrosis, nonunion, irrecoverable crush injury, unsalvageable muscle injury and skin loss, extensive bone loss, osteomyelitis, articular damage to the foot, or wound infection).[4] Acute CS is recognized as one of the most serious complications of limb trauma, with timely fasciotomy as the only available gold standard treatment.[18,31] Post-fasciotomy complications are common[10,12,32] and are not inconsequential; delays in timely intervention have the potential to lead to a limb amputation.[33] Previous studies have demonstrated that tibial fractures are the primary cause of acute limb CS,[20] requiring emergency surgical decompression of all involved leg compartments.

We undertook this large tibia fracture population study, using patients in the province of Ontario, to investigate the occurrence of fasciotomy and amputation, as well as to evaluate the association between patient and fracture characteristics with each of these outcomes. It was found that almost half of all tibial fracture patients in Ontario (47%) required post-fracture admission to the hospital, and 1.7% required fasciotomy. Of all the patients who needed fasciotomy, over 3 quarters were male (76%) and 70% were younger than 50 years; older patients of either sex were less likely to require fasciotomy. Several previous reports have also shown that male sex and age (younger than 35 years) are risk factors of CS and fasciotomy,[20,34,35] presumably because younger male patients are more likely to suffer a high-energy (ie, more severe or complex) fracture. However, it is noteworthy that in this study, both male sex and younger age were found to be significantly associated with having fasciotomy, even after adjusting for polytrauma.

There was a nearly 6-fold increase in the need for fasciotomy in polytrauma patients, possibly indicating that a combination of injuries (rather than just a single tibial fracture) has the potential to systemically amplify the severity of the patient's condition. Alternatively, the higher energy mechanism associated with polytraumatized patients would be expected to have a direct

TABLE 3

Logistic Regression Analysis Investigating Fasciotomy Within 14 days of Tibial Fracture

Variable	Odds Ratio	95% Confidence Interval		P
		Lower	Upper	
Patient age (quintile 1 vs. 5)	1.81	1.43	2.28	<0.0001
Patient age (quintile 2 vs. 5)	2.39	1.91	2.98	<0.0001
Patient age (quintile 3 vs. 5)	2.42	1.94	3.03	<0.0001
Patient age (quintile 4 vs. 5)	1.58	1.24	2.01	0.000
Patient sex (male vs. female)	2.09	1.83	2.39	<0.0001
Polytrauma (yes vs. no)	5.79	5.17	6.47	<0.0001
Fiscal year (2004 vs. 2003)	0.93	0.72	1.21	0.581
Fiscal year (2005 vs. 2003)	0.96	0.74	1.24	0.740
Fiscal year (2006 vs. 2003)	0.81	0.62	1.05	0.114
Fiscal year (2007 vs. 2003)	0.75	0.57	0.98	0.033
Fiscal year (2008 vs. 2003)	0.61	0.46	0.81	0.001
Fiscal year (2009 vs. 2003)	0.63	0.47	0.83	0.001
Fiscal year (2010 vs. 2003)	0.68	0.52	0.90	0.006
Fiscal year (2011 vs. 2003)	0.58	0.44	0.77	0.000
Fiscal year (2012 vs. 2003)	0.70	0.53	0.91	0.009
Fiscal year (2013 vs. 2003)	0.61	0.47	0.80	0.000
Fiscal year (2014 vs. 2003)	0.48	0.36	0.64	<0.0001
Fiscal year (2015 vs. 2003)	0.50	0.38	0.66	<0.0001

Age quintile 1 = 14–25, quintile 2 = 26–41, quintile 3 = 42–53, quintile 4 = 54–66, and quintile 5 = 67+ years of age.

TABLE 4

Logistic Regression Analysis Investigating Amputation and Repeat Surgery

Variable	Amputation		Repeat Surgery*	
	Odds Ratio (95% CI)	P	Odds Ratio (95% CI)	P
Age (per 10-y increase)	1.03 (1.02–1.03)	<0.0001	0.83 (0.77–0.90)	<0.0001
Sex (male vs. female)	2.04 (1.63–2.55)	<0.0001	1.54 (1.14–2.07)	0.0053
Polytrauma (yes vs. no)	9.37 (7.64–11.50)	<0.0001	4.24 (3.33–5.38)	<0.0001
Fasciotomy (yes vs. no)	4.35 (3.21–5.90)	<0.0001		

* Analysis restricted to subgroup of patients who underwent fasciotomy.

relation with increased tibia fracture energy and thus of compartment syndrome.

Under normal circumstances, the rate of amputation due to tibial fractures is fairly low,[31] provided fasciotomy is performed in a timely manner. Given that polytrauma patients frequently experience an altered level of consciousness, a timely diagnosis of CS can be challenging, particularly if it is only based on the clinical examination.[36] In our study, of the variables investigated, the presence of polytrauma had the largest association with the need for limb amputation, even after adjusting for age, sex, and fasciotomy. Male patients were more likely to require an amputation than female patients while older age had a small, albeit significant, association with increased risk of amputation. Normally, given that delayed fasciotomy is more likely to result in amputation,[33] surgeons need to be extra vigilant with polytrauma patients, making judicial use of serial evaluations and compartment pressure monitoring, particularly when male patients with tibial fractures are involved, performing fasciotomy early rather than late.

Interestingly, our data indicate that time to fasciotomy was significantly shorter for those who ultimately underwent limb amputation compared with those who did not (0.8 vs. 1.5 days, 62.5% vs. 34.2% performed on the day of fracture). Severe injuries were identified and treated quickly, yet clearly were more likely to result in an amputation. Timely intervention is always required after diagnosis of CS; the observed association between fasciotomy and subsequent amputation is likely reflective of the severity of the initial injury, rather than a causal relationship.

The odds of repeat surgery were also found to be higher in polytrauma patients with fasciotomy. This is not surprising, given that the standard of care of a surgically managed limb is to re-examine it in the operating room 48 hours after fasciotomy for debridement of necrotic muscle and/or delayed closure.[37,38] Moreover, polytrauma is very likely associated with higher energy injuries, requiring more complex soft-tissue reconstruction (not just delayed primary closure).

Our study was not without limitations. While it involved a large cohort of patients and is likely representative of the Ontario population in terms of sex, age, socioeconomic groups, comorbidity distributions, and other prognostic factors, the study was based on the use of billing codes, carrying a risk of misclassification if codes were not used properly. We were also limited by the data available within the administrative data sets used for this study. In particular, we made the assumption that the performance of fasciotomy indicated the presence of CS; however, we could not distinguish between fasciotomy performed for a true CS versus prophylactic fasciotomy or one undertaken during a revascularization procedure. We also lacked data reflecting the cause and severity of the initial trauma and were unable to distinguish between high-energy (eg, Gustilo grade 3B or 3C, or OTA/AO Open Fracture Classification [OFC] Severe) versus low-to-mid-energy fractures (although it can be surmised that open fractures would most likely be those of higher energy). Consequently, we relied on a novel definition of polytrauma that had not previously been validated; nevertheless, our definition of polytrauma aligned well with the OHIP ISS indicator[27,28] and was highly associated with both fasciotomy and adverse outcomes after fasciotomy. It should be noted that in this study, it was not possible to conduct formal chart reviews of all patients, and therefore, our data may not distinguish between the exact reason for amputation (eg, mangled limb/severity of the initial injury, nonunion, infection, intractable pain, missed compartment syndrome, or post-traumatic arthritis). Moreover, it also precluded us from assessing the relationship of associated injury to amputation.

In conclusion, among patients older than 14 years with tibial fracture, patients who are male and who experience polytrauma are at significantly increased risk of undergoing both fasciotomy and amputation. Age had a nonlinear association with fasciotomy, with those in the oldest quintile being the least likely to undergo fasciotomy, while increasing age had a small but significant association with risk of amputation. Fasciotomy was also significantly associated with risk of amputation, even after adjusting for age, sex, and polytrauma, a finding that is likely reflective of the severity of the initial injury. It is also possible that some of the fasciotomies were performed after the onset of CS (ie, too late) and the resultant exposure of necrotic muscle or the presence of infection may have contributed to the amputations. Given the lack of a reliable diagnostic test that is predictive of the presence of acute CS, this remains an important area for research.

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