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Outcomes of midfoot and hindfoot fractures in multitrauma patients

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ABSTRACT

Introduction: Multitrauma patients suffering hindfoot fractures, including calcaneal and talar fractures, often result in poor outcomes. However, less is known about the outcomes following midfoot fracture in the mutitrauma population. This study aims to describe the epidemiology of midfoot fractures in multitrauma patients and to compare the outcomes of midfoot and hindfoot fractures in this population.
Methods: Data about multitrauma patients (Injury Severity Score >12) sustaining a unilateral midfoot or hindfoot fracture were obtained from the Victorian Orthopaedic Trauma Outcomes Registry (VOTOR) and from retrospective review of medical records at a major trauma centre. Further outcome data were obtained via a survey using the American Academy of Orthopedic Surgeons Foot and Ankle Score (AAOS FAS) and the 12-item Short Form Health Survey (SF-12).
Results: 122 multitrauma patients were included; 81 with hindfoot fractures and 41 with midfoot fractures. The median ISS (IQR) was 22 (17–29) and 27 (17–24) for the hindfoot and midfoot groups, respectively (p = 0.23). Hindfoot and midfoot fractures were commonly associated with intracranial injuries (80.3%), spine injuries (60.7%), ipsilateral lower extremity injuries (24.6%) and pelvic injuries (16.4%). The mean (SD) time to follow up was 4.5 (±2.7) years. There were no differences in mean SF-12 physical (37.97 vs 35.22, p = 0.33) or mental (46.90 vs 46.67, p = 0.94) component summary scores between the groups. There were no differences in mean AAOS FAS standard scores (69.3 vs 69.1, p = 0.97) or shoe comfort scores (median 40 vs 40 p = 0.18) between the groups.
Conclusion: Functional outcomes in multitrauma patients with midfoot or hindfoot fractures were comparable. These findings suggest that midfoot fractures should be treated with the same degree of due diligence as hindfoot fractures in the multitrauma patient.

Introduction

Foot fractures can be divided regionally into forefoot, midfoot and hindfoot fractures. A broad range of fractures, dislocations and combinations of injuries exist including simple fractures, fracture-dislocations, pure dislocations and the so-called “crushed foot” [1]. These fractures commonly occur in the setting of motor vehicle crashes, or falls from a height, and are often associated with lower limb, pelvic and spine injuries [2]. Midfoot fractures account for only 10% of total foot and ankle trauma, this compares to 17% for hindfoot fractures [3].

Foot fractures have been shown to be a cause of long-term disability and contribute to worse functional outcomes in multitrauma patients [2,4–6]. In particular, patients with hindfoot fractures frequently progress to posttraumatic arthritis requiring additional surgical procedures, principally arthrodesis of the subtalar and ankle joints, to manage their resulting pain and disability [7–10]. Intra-articular calcaneal fractures were found to progress to require secondary arthrodesis in 21% of patients in the Netherlands, with an estimated annual socio-economic cost of 21.5–30.7 million Euro [11]. These patients demonstrate considerably poorer functional outcome measures when compared to a normal population [12,13]. Overall there is a lack of data on the outcomes of midfoot fractures as a region, with the exception of Lisfranc injuries [14]. There are variable outcomes demonstrated between fracture patterns with isolated cuneiform, navicular or cuboid fractures without dislocation demonstrating favourable prognoses in comparison to Lisfranc fracture-dislocations [15].

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An impaired outcome associated with hindfoot fractures in the multitrauma patient is generally accepted. Only one study has investigated functional outcomes in midfoot fractures as a group [15]. Whether midfoot fractures carry a similar burden of disability to hindfoot fractures in multitrauma patients remains unclear. This study aims to describe the epidemiology, and compare the long-term functional outcomes, of midfoot and hindfoot fractures in the multitrauma population at a major trauma centre.

Methods

Setting

Victoria is Australia's second most populous state, with a population of 5.8 million and an annual growth rate of 1.9% [16]. Servicing this population is The Alfred Hospital, one of two adult major trauma centres in Victoria, and a university-affiliated tertiary referral hospital located in Melbourne. Data for this study were sourced from patients admitted to The Alfred Hospital and registered by the Victorian Orthopaedic Trauma Outcomes Registry (VOTOR). This registry prospectively records data from all adult orthopaedic trauma patients admitted for greater than 24 h at four participating hospitals. Patients are recruited using an opt-out method of consent, with less than 2% choosing to opt-out [17].

Procedures

The study included patients who presented to The Alfred hospital between March 2005 and December 2009. All recruited patients identified through the VOTOR were then cross-referenced against the Victorian State Trauma Registry (VSTR) [18], a state-based database which collects additional data on patients who meet the major trauma definition of an Injury Severity Score (ISS) greater than 12 [19] or an ICU stay of more than 24 h requiring mechanical ventilation. International Classification of Diseases 10th Revision-Australian Modification (ICD-10-AM) codes were used to identify patients with a midfoot fracture or hindfoot fracture. All identified injuries were confirmed by review of initial radiographs and CT scans where available.

Patient data was divided into two groups, those with a unilateral midfoot fracture and those with a unilateral hindfoot fracture. Patients with bilateral foot fractures or an ipsilateral combined midfoot and hindfoot fracture were excluded. Isolated capsular or tarsal bone avulsions (except where they were Lisfranc fractures) were excluded. Midfoot fractures included Lisfranc fracture-dislocations, cuneiform, navicular and cuboid fractures. Hindfoot fractures included Chopart fracture-dislocations, talus and calcaneal fractures. Metatarsal and phalanx fractures constituted the forefoot for classification purposes, the presence of which did not exclude the midfoot or hindfoot patient from recruitment.

The primary outcomes were the Short Form Health Survey (SF-12) [20] and the American Academy of Orthopedic Surgeons Foot and Ankle Score (AAOS FAS) [21]. A 6 and 12-month SF-12 is recorded by VOTOR. In addition, a mailed survey requested completion of the AAOS FAS and a current SF-12. Written instructions were included to aid completion of the surveys. If no response was received, the patient was contacted by telephone and offered the chance to complete their responses over the phone. Where no response to the additional survey was obtained, the last SF-12 score from the VOTOR database was used as latest follow-up and no AAOS FAS could be recorded. The SF-12 is a generic self-administered questionnaire composed of 12 questions. Responses to these questions allow the calculation of a Physical Component Summary (PCS) and a Mental Component Summary (MCS). The AAOS FAS is a validated region-specific tool composed of a 5-question shoe comfort scale and a 20-question global foot and ankle scale. It has been shown to have a high correlation with other commonly used scores in the literature, including the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale [21,22]. The AAOS standardised score provides a value between 0–100 with 100 being a perfect result.

Demographic data were sourced from VOTOR. VOTOR patients are asked to if rate they had a pre-injury disability (none, mild, moderate or severe), for the purposes of this study this data was dichotomised into a "yes" or "no". Cause of injury, treatment, comorbidities and complication details were retrospectively sourced from the medical record.

Data analysis

Data are presented as percentages for categorical variables, mean (standard deviation) for continuous variables if data were parametric, and median (interquartile range - IQR) if data were skewed. Continuous variables including age and ISS, and categorical variables including gender, ICU stay, smoking status, fund (compensable/non-compensable), Charlson Comorbidity Index (CCI) and cause of injury were compared between the hindfoot and midfoot groups. Univariate comparisons included chi-square tests for categorical or dichotomous data and the Mann-Whitney *U*-test for continuous data. The AAOS shoe comfort score and standard score were also compared between the two groups. The SF-12 PCS and MCS scores at the longest time point from injury (in months) were analysed. Factors with a univariate association of ($p < 0.25$) with the outcome (SF-12 PCS or MCS) were included in a linear regression analysis. Time since the injury was also included in this analysis to adjust for the variability in follow-up time. A p-value <0.05 was considered significant. All analyses were performed using Stata Version 13.2 (StataCorp, College Station, TX, USA).

Ethics

Ethics approval was obtained from The Alfred Health Human Ethics Committee (approval number 348-09).

Results

There were 130 multitrauma patients with midfoot or hindfoot fractures. Eight were excluded as they had a combined midfoot and hindfoot injury, leaving 122 multitrauma patients with a mean (SD) age of 37.7 (17.2) years. Most patients were male (68%). Eighty-one (66%) patients had sustained a hindfoot fracture and 41 (34%) had sustained a midfoot fracture. The patient demographics are shown in Table 1. There were no significant differences between the hindfoot and midfoot groups.

Amongst the 81 hindfoot patients, there were a total of 107 coded injuries in the hindfoot region, with an additional 10 forefoot fractures. In the midfoot group of 41 patients, there were 66 midfoot fractures and 32 associated forefoot fractures. Overall there were 60 talar fractures, 40 calcaneal fractures, 7 Chopart fracture-dislocations, 15 Lisfranc fracture-dislocations, 21 cuneiform fractures, 15 cuboid fractures and 15 navicular fractures. Eighteen (22.2%) patients had two hindfoot fractures in the same foot and three (3.7%) patients had all three (calcaneus, talus and Chopart) hindfoot fractures. In the midfoot group, 10 (24%) patients had two foot fractures, five (12%) had three, and one (2.4%) patient sustained all four midfoot (cuneiform, navicular, cuboid and Lisfranc) fractures in the same foot.

The associated injuries are shown in Table 2. There were eight (9.9%) patients with open fractures in the hindfoot group, four (4.9%) of which had wounds greater than 10 cm or had extensive soft tissue damage (Gustilo III). In the midfoot group, there were

Table 1
Demographics.

		Hindfoot (n = 81)	Midfoot (n = 41)	*P*-value
Age (mean, SD)		37.6 (17.5)	38.0 (16.6)	0.82
Gender	Male	53 (65.4%)	30 (73.2%)	0.39
Smoking status	Yes	27 (33.3%)	14 (34.1%)	0.93
Diabetes	Yes	6 (7.4%)	2 (4.9%)	0.59
ICU Stay	Yes	43 (53.1%)	22 (53.7%)	0.95
Mechanism	Motor-vehicle	54 (66.7%)	27 (65.9%)	0.06
	Motorcycle	13 (16.0%)	6 (14.6%)	
	High Fall (> 2 m)	8 (9.9%)	0 (0 %)	
	Other	6 (7.4%)	8 (19.5%)	
Injury Severity Score (median, IQR)		22 (17–29)	27 (17–24)	0.23
Charlson Comorbidity Index weight	0	45 (55.6%)	25 (61.0%)	0.70
	1	28 (34.5%)	14 (34.1%)	
	>1	8 (9.9%)	2 (4.9%)	
Compensable injury	Yes	71 (87.7%)	35 (85.4%)	0.72
Pre-injury disability[a]	Yes	9 (16.1%)	3 (12.0%)	0.82
Discharge destination	Home	22 (27.2%)	10 (24.4%)	0.74
	Inpatient rehabilitation	59 (72.8%)	31 (75.6%)	
Working prior to injury[b]	Yes	55 (80.9%)	28 (73.7%)	0.39

Data in n (%) unless otherwise stated.
Missing data: [a] n = 25 hindfoot, 16 midfoot; [b] n = 13 hindfoot, 3 midfoot.

Table 2
Associated Injuries.

	Hindfoot (n = 81)	Midfoot (n = 41)	*P*-value
Ipsilateral lower extremity injury	16 (19.8%)	14 (34.1%)	0.08
Contralateral lower extremity injury	7 (8.6%)	3 (7.3%)	0.65
Bilateral lower extremity injury	3 (3.7%)	2 (4.9%)	0.76
Pelvic fracture	11 (13.6%)	9 (22.0%)	0.24
Spinal fracture	51 (63.0%)	23 (56.1%)	0.46
Intracranial injury	66 (81.5%)	32 (78.0%)	0.65

five (12%) patients with open fractures, with only one (2.4%) being classified as Gustilo III.

Treatment

Hindfoot fractures

Talus fractures were treated with open reduction and internal fixation in 27 cases. Sixteen calcaneus fractures were treated with open reduction and internal fixation. One patient identified with a calcaneus fracture required a below knee amputation due to an unsalvageable concurrent open tibial plafond injury with neurovascular compromise. Chopart fracture-dislocations were treated with open reduction and internal fixation in six cases. Of the hindfoot patients, seven required an initial external fixator prior to definitive fixation. Nine other hindfoot patients had an external fixator for an ipsilateral ankle fracture. No primary arthrodesis procedures were performed.

Midfoot fractures

Seven cuboid fractures were managed with open reduction and internal fixation, with two of these patients managed with bridging plates that were secondarily removed. Navicular fractures were managed with open reduction and internal fixation in four cases. Ten cuneiform fractures were managed with open reduction and internal fixation. Lisfranc fracture-dislocations were operatively managed in 12 cases; three patients had bridging plates inserted and seven patients had screw fixation that were secondarily removed. An example of Lisfranc fixation with screws and K-wires to the tarsometatarsal joints is shown in Fig. 1. One midfoot patient with a combined Lisfranc, cuneiform and navicular fracture was initially managed with an external fixator prior to definitive fixation. One midfoot patient had an external fixator applied for treatment of an associated ankle fracture. Primary arthrodesis was not performed in the midfoot group.

Overall, 49 (45.8%) hindfoot fractures were treated with internal fixation compared to 33 (50.0%) midfoot fractures (p = 0.59).

In-hospital complications

Five (6.2%) patients in the hindfoot group sustained a wound-related complication (including infection), two (2.5%) had a thromboembolic event, and one (1.2%) patient developed compartment syndrome of the foot. Three (7.3%) patients in the midfoot group developed a wound-related or infection complication.

Outcomes

The long-term results are shown in Table 3. The mean (SD) time of latest follow-up was 53.7 (32.0) months. The AAOS FAS survey was completed for 57% (n = 46) of hindfoot patients and 49% (n = 20) of midfoot patients. The SF-12 scores were completed for 84% (n = 68) of hindfoot patients and 66% (n = 27) of midfoot patients.

Physical Health: After considering age, gender, mechanism of injury, other lower extremity injuries and time since injury, there was no difference in the mean SF-12 PCS scores between the hindfoot and midfoot groups (p = 0.54).

Mental Health: After taking into account age, gender, mechanism of injury, other lower extremity injuries and time since injury, there was no difference in the mean SF-12 MCS scores between the hindfoot and midfoot groups (p = 0.68).

Discussion

It is well understood that foot fractures contribute to a worse outcome in the multitrauma setting [2,4–6], however a regional comparison between hindfoot and midfoot fractures to further delineate outcomes has not been performed. This study reviewed hindfoot and midfoot fractures, including fracture-dislocations, in the multitrauma patient and showed no significant difference in long-term outcomes between the two groups both in their generic health questionnaire and region-specific AAOS foot and ankle scores. Both the hindfoot and midfoot groups showed impaired

Fig. 1. A) Pre-operative radiograph demonstrating a Lisfranc fracture-dislocation with widening of the 1st and 2nd intermetatarsal space and subluxation of the 2nd-5th metatarsals. B) Post-operative fixation of the midfoot with cannulated screws and Kirschner wire fixation to the tarsometatarsal joints.

Table 3
Survey Results at Latest Follow-up.

		Hindfoot	Midfoot	P value
Return to work (if work prior)[a] (n, %)	Yes	34 (69.4%)	15 (71.4%)	0.86
AAOS Foot & Ankle Global Raw Score		69.28 (21.02)	69.10 (22.78)	0.97
AAOS Foot & Ankle Shoe Comfort Score (median, IQR)		40 (25-80)	40 (22.5–55)	0.18
SF-12 Physical component summary (PCS)[b]		37.97 (12.74)	35.22 (11.42)	0.33
SF-12 Mental component summary (MCS)[b]		46.90 (12.98)	46.67 (12.07)	0.94

Data in mean (SD) unless otherwise stated.
[a]Missing data or no work prior: n = 32 hindfoot, n = 20 midfoot. [b]Norm-based scores standardised to a population mean of 50 ± 10 (mean, SD) with lower scores representing reduced quality of life.

long-term results on their patient reported outcome measure (AAOS FAS) and their general health questionnaire (SF-12). This study is the first to provide information that midfoot fractures may result in similar outcomes to hindfoot fractures in the multitrauma population.

A study by *Richter et al.* [15] demonstrated long-term impairment in midfoot fractures in a study of 155 patients (63% follow-up of mean nine years). Richter's study found that Chopart and Lisfranc fracture-dislocations produced worse results compared to isolated fractures of the midfoot. The outcomes of these fracture-dislocations improved to approach that of isolated fractures following surgical fixation, suggesting that the appropriate treatment of these injuries is important in improving long-term sequelae [15,23]. *Frink et al.* [24] similarly demonstrated that simple, isolated foot fractures pose better long-term outcomes than fracture-dislocation patterns. A recent paper by *van der Vliet et al.* [25] looked at the functional outcomes post Lisfranc and Chopart internal fixation and found similarly impaired region-specific scores and overall quality of life scores. Their paper also inferred that these results are comparable to the outcomes seen in severe, intra-articular calcaneal fractures. *Richter et al.* and *van der Vliet et al's* papers used a different region-specific outcome measure than this paper, the American Orthopaedic Foot and Ankle Score (AOFAS). Although a direct comparison of our outcomes is not possible, all three papers have now shown a trend towards impaired long-term outcomes in midfoot fractures. Subgroup analysis by type of fracture in our study was not performed due to insufficient numbers to adequately power the analysis. Nonetheless, our study provides further information to supplement the available literature that describes foot fractures as pronounced contributors to patient morbidity in the multitrauma setting [4–6]. This provides some confidence that the midfoot fracture needs to be carefully considered in the primary assessment and management of the multitrauma patient and that the morbidity associated with the long-term outcome is not less than that associated with hindfoot injury. There is a hierarchy of importance when managing the mutitrauma patient and clearly midfoot injuries are of lesser importance than the majority of other priorities. However, we have shown that midfoot injuries do lead to significant disability and that the magnitude of that disability equals that seen in hindfoot injuries – a well-recognized source of significant disability. Hence it is important to allocate an appropriate degree of importance to this injury and its management, even in the presence of other significant priorities.

The only difference between groups in our cohort was the mechanism of injury, with hindfoot fractures more often resulting from high falls (10% vs 0%). Motor vehicle crashes were the cause of over 65% of injuries in both groups. *Richter et al's* study found 12% of midfoot patients resulted from falls, with motor vehicle crashes similarly being the most common cause of injury at 72% [15], a result that was also demonstrated in their paper from the German trauma registry [2]. Both previous studies reported a higher percentage of patients with a lower extremity injury (up to 81% in foot and ankle patients, and 71% in midfoot patients) in comparison to our results which favoured cranial, spinal or pelvic injuries as the most common associated injury, with only 37% of our patients sustaining a lower extremity injury. Our results may be skewed to having more patients with concomitant head injuries as our inclusion criteria was admission to ICU, with a common cause of ICU admission being head trauma requiring intubation. Importantly, both groups in our study had a high rate of compensable injury status (88% hindfoot and 85% midfoot), a factor known to be associated with poorer outcomes.

Outcomes in foot trauma are affected by several factors. Foot fractures are the most frequently missed orthopaedic diagnosis on plain radiographs, with an estimated 7.6% missed on initial radiograph reports in the emergency setting [26]. In particular, Lisfranc fracture-dislocations are missed in up to 20% of cases [27]. This may be more prevalent in the multitrauma population where there are potentially numerous distracting injuries and additionally, an impaired conscious state. Modern improvements in recognition and further CT evaluation of foot injuries has demonstrated a significantly higher incidence of midfoot injuries than previously estimated [28]. Despite this, *van der Vliet et al.* [29] found that 30% of foot fractures in the multitrauma setting are diagnosed in a delayed fashion. As a result, 8% of their cohort suffered treatment consequences due to this delay. A missed diagnosis can result in delayed treatment or an altered treatment plan thereby impacting negatively on the anticipated outcome.

The major strength of this study was the large sample size compared to previous studies of long-term functional follow-up of multitrauma patients with midfoot fractures. Our study is unique in that it collected generic health status (SF-12), as well as a region-specific, patient reported outcome scores via the AAOS Foot and Ankle questionnaire.

One limitation was the lack of patients' surgical management follow-up, as only initial in-hospital management was recorded. The low follow-up for our AAOS FAS survey was another limitation of the study; however, the overall outcomes were well captured by the generic health scores recorded through the registry.

Conclusion

Midfoot fractures and hindfoot fractures have similar epidemiology and outcomes. These results suggest that midfoot and hindfoot fractures should both be assessed and managed with a high degree of due diligence in the multitrauma patient to improve long-term outcomes.

Conflict of interest

None of the authors have any conflicts of interest to declare in relation to this work.

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