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A Trauma System wide Evaluation of the Demographic, Injury and Fracture Characteristics of Patients with Calcaneal Fractures: A Comparison of Trauma Level I and II Centers

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Abstract

Introduction: Calcaneal fractures are known to influence patients daily lives negatively. Different levels of trauma centers face a diversity of patients who sustained a calcaneal fracture. Little is known about the demographic, trauma and fracture characteristics for these patients. Moreover, the differences in these characteristics between different levels of trauma care. Knowledge of this is needed, to improve the outcome in these patients. In this study we evaluate in detail the characteristics of patients with a calcaneal fractures in a regional inclusive trauma system.

Material and Methods: This is a retrospective regional cohort study of prospectively collected data. All patients aged 16 years or older with a calcaneal fracture admitted in one of the participating trauma level I or II hospitals were included. Patients', trauma and fracture characteristics were collected.

Results: A total of 285 patients with 307 calcaneal fractures were eligible for analysis. A mechanism of trauma was in most patients a fall from height, followed by a simple fall. The greater majority of the accidents occurred in domestic circumstances, 70% of the patients had an isolated calcaneal fracture. The trauma level I population (n= 72) was significantly younger, sustained a more severe injury with more concomitant injuries, and 26% had a psychiatric history.

Conclusion: This study demonstrates, that there are substantial differences between the level I and II trauma centers in the demographic patterns and injury characteristics in patients with a calcaneal fracture. These differences should be accounted for in the interpretation of results according to the level of trauma care that a particular hospital offers. Additionally, in the trauma level II centers more low-complex calcaneal fractures and distinctively other subgroups (e.g. elderly) are admitted that might benefit from customized management to adapt to their specific needs.

Keywords: Calcaneal fracture; Epidemiology; Fractures; Calcaneus; Trauma care

Level of Evidence

Level 3, a retrospective study of prospectively collected data

Introduction

Calcaneal fractures are a relatively uncommon injury that are known to influence the daily lives of patients negatively [1-4]. Most studies tend to focus on comparing treatments in patients with an intra-articular fracture including all different levels of trauma centers, mainly from trauma level I centers. The inclusion of patients from different trauma center levels might skew the outcome results [1]. To gain knowledge in the likely heterogeneity of demographic and injury characteristics in patients with calcaneal fractures, evaluation of patients in a large and consecutive cohort is needed. Furthermore, in

current trauma care, different levels of trauma centers face a diversity of patients who sustained a calcaneal fracture. Many countries developed a trauma system to improve and coordinate the care for the injured [5]. A regionalized care approach was established with a combination of levels of designated trauma centers; the efficacy of this approach has been demonstrated in terms of better triage and improved patient outcomes [6-9]. Knowledge on the demographic and injury patterns, and the differences in these patterns between level I and II centers may help improve the expectations of the outcome in patients with a calcaneal fracture. In addition, insight in these patterns may aid interpreting the results from different levels of trauma care and might help policy makers in optimizing the use of the scarce resources (e.g. to establish clinical pathways). The aim of this study is two-fold. First, to evaluate in detail the demographic, injury and fracture patterns within a trauma region. Second, to study the differences in patient, trauma and fracture characteristics between trauma centers of different level of trauma care in a regional inclusive

trauma system. To our knowledge, this is the first study on calcaneal fractures that compares trauma centers with a different care level.

## Material and Methods

Hospital setting

This study was conducted in the central trauma region of the Netherlands. Four trauma centers, functioning in this region, participated in this study, one level I trauma center (University Medical Center Utrecht) and three level II trauma centers (St. Antonius Hospital, Diakonessen Hospital and Meander Medical Center).

Study design

This is a retrospective study of prospectively collected data, performed under the approval of the medical ethics committee of the University Medical Center Utrecht in the Netherlands.

Data collection

We used three databases to identify all patients diagnosed with a calcaneal fracture. The Dutch National Medical registration, this registry is a national database in which all hospital admissions are collected with concomitant diseases or injuries coded according to the International Classification of Diseases (ICD) [10,11]. The hospital databases, in which calcaneal fractures are coded based upon diagnosis. The regional trauma registry, which records all admitted trauma patients in the trauma region and codes all injuries according to the Abbreviated Injury Scale score and ICD [10,12]. All three databases register patients prospectively and in a standardized manner. We have excluded all duplicates and patients that were initially diagnosed with a calcaneal fracture in another hospital (Figure 1).

Figure 1: Flow chart of enrolled patients.
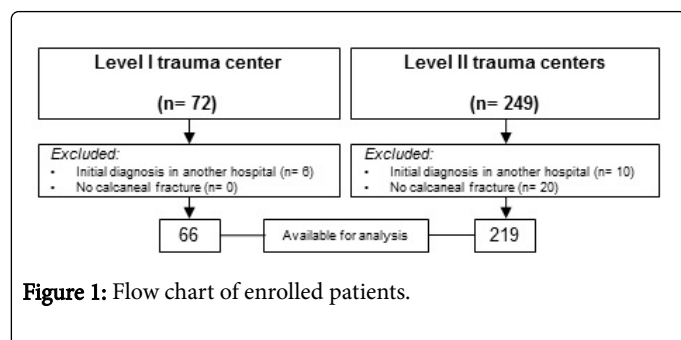
We have included all patients aged 16 years or older diagnosed with a calcaneal fracture in 2010 through 2012. All data were extracted from the patients' medical record or trauma registry. We collected all patient demographic data such as age, gender, comorbidities categorized according to the ASA Physical Status Classification System, psychiatric history, trauma mechanism, circumstances of trauma, Injury Severity Score (ISS), concomitant injuries, type of calcaneal fracture, fracture classification by Sanders and primary treatment of fracture [13-15].

Preferable, CT-images were used to assess the type of fracture. When no CT-image was available, the conventional radiographic images were used.

Statistical analysis

A descriptive analysis was performed to compare patient, trauma and fracture characteristics between the trauma level I and level II populations. Categorical variables were compared using Chi-square test, and continuous variables were compared using Student's T or Mann-Whitney U test. A P-value<0.05 was considered statistically significant. All data were analyzed with IBM SPSS Statistics for Windows Version 20.0 [16].

Results

A total of 321 patients who sustained a calcaneal fracture were identified in the databases. Twenty patients were incorrect registered with a calcaneal fracture; these patients were excluded after revision of the medical records and radiographic images. In total 285 patients with 307 calcaneal fractures were available for analysis. The majority of the patients (n=219) were diagnosed at the level II trauma centers. Tables 1 and 2 show the baseline patients, trauma and fracture characteristics.

Patient characteristics

Patients who have been diagnosed with a calcaneal fracture in the level I trauma center are significantly younger than patients in the level II trauma centers (p=0.014). Moreover, none of the patients in the level I population was 70 years or older in contrast to the 11% in the level II centers (p=0.005). Independently of level of trauma care, a calcaneal fracture occurred approximately 1.5 times more often in males.

There was no difference in the severity of the comorbidities of the patients between the different levels of trauma care. The majority (± 75%) had an ASA I classification. However, a significant number of patients (26%) admitted at the trauma level I center had a psychiatric history (p<0.001).

Characteristics	Level I	Level II	Total
Number of patients	66	219	285
Age at trauma in years†‡	37 (25-50)	49 (35-64)	47 (33-60)
Age at trauma 70 years or older*‡	0 (0)	24 (11)	24 (8)
Female*	27 (41)	89 (41)	116 (41)
Comorbidities before trauma*			
ASA I	52 (79)	157 (72)	209 (73)

ASA II	12 (18)	51 (23)	63 (22)
ASA III	2 (3)	11 (5)	13 (5)
Diabetes mellitus before trauma*	2 (3)	15 (7)	17 (6)
Psychiatric history before trauma*‡	17 (26)	18 (8)	35 (12)
Circumstances of trauma*‡			
Domestic‡	22 (33)	129 (59)	151 (53)
Psychiatric episode‡	10 (15)	1 (1)	11 (4)
Recreational	5 (8)	24 (11)	29 (10)
Road traffic accident‡	19 (29)	22 (10)	41 (14)
Work	9 (14)	21 (10)	30 (11)
Unknown or other‡	1 (2)	22 (10)	23 (8)
Mechanism of trauma*‡			
Fall from height ≥ 1.5 meter	37 (56)	95 (43)	132 (46)
Simple fall <1.5 meter‡	2 (3)	76 (35)	78 (27)
Crush	3 (5)	4 (2)	7 (3)
Motor vehicle accident‡	19 (29)	9 (4)	28 (10)
Sports/leisure	0 (0)	7 (3)	7 (3)
Other or unknown	0 (0)	5 (3)	5 (2)
Inversion trauma	5 (8)	21 (10)	26 (9)
Injury Severity Score†‡	5 (4-14)	4 (4-4)	4 (4-4)
Injury Severity Score ≥ 16*‡	16 (24)	1 (0)	17 (6)
Associated injuries*‡			
Isolated calcaneal fracture‡	18 (27)	181 (83)	199 (70)
Only lower limb associated injuries‡	13 (20)	19 (9)	32 (11)
Only one other associated injury	5 (8)	9 (4)	14 (5)
Multiple injuries‡	30 (50)	10 (5)	40 (14)
Concomitant injuries per region*			
Spinal fracture‡	19 (29)	5 (2)	24 (8)
Pelvic fracture (excluding sacrum)‡	12 (18)	1 (0)	13 (5)
Upper limb injury‡	16 (24)	8 (4)	24 (8)
Head injury‡	15 (23)	3 (1)	18 (6)

Thoracic injury‡	13 (20)	5 (2)	18 (6)
Abdominal injury‡	6 (9)	0 (0)	6 (2)
Lower limb injury‡	38 (58)	28 (13)	66 (23)
Bilateral calcaneal fracture*	7 (11)	15 (7)	23 (8)
*=Number (Percent within population); †=Median (Interquartile range); ‡=p<0.05 in level I versus level II			

Table 1: Baseline of patients and trauma characteristics.

Characteristics	Level I	Level II	Total
Number of patients	66	219	285
Number of calcaneal fractures	73	234	307
Open calcaneal fracture*‡	13 (18)	5 (2)	18 (6)
Type of calcaneal fracture*‡			
Fracture into talar surface	41 (56)	109 (47)	15 (49)
Isolated anterior surface fracture	15 (21)	32 (14)	110 (15)
Isolated extra-articular fracture‡	17 (23)	93 (40)	47 (36)
CT-imaging*‡			
Sanders type I	2 (3)	7 (3)	9 (3)
Sanders type II	14 (19)	52 (22)	66 (22)
Sanders type III	10 (14)	34 (15)	44 (14)
Sanders type IV‡	12 (16)	7 (3)	19 (6)
Isolated extra-articular fracture‡	10 (14)	24 (10)	34 (11)
Isolated anterior surface fracture‡	10 (14)	15 (6)	25 (8)
Not available‡	15 (21)	95 (41)	110 (36)
Primary treatment*‡			
Operative‡	28 (38)	56 (24)	84 (27)
Non-operative‡	42 (58)	172 (74)	214 (70)
Unknown	3 (4)	6 (3)	9 (3)
*=number (Percent within population); †=Median (Interquartile range); ‡=p<0.05 in level I versus level II			

Table 2: Baseline of fracture characteristics.

Trauma mechanism and injury characteristics

The calcaneal fractures occurred most often in domestic circumstances independently of trauma level. However, in the level I trauma center the calcaneal fracture occurred significantly more often during a psychiatric episode (e.g. during psychosis, depression or schizophrenic episode; p<0.001) or road traffic accident (p<0.001) in comparison with the level II trauma centers. Furthermore, there is a significant difference between the trauma mechanisms of the injured patients in the centers (p<0.001). In both populations a fall from height was in ± 50% of the patients the most common cause of a calcaneal fracture, followed by minor falls in the level II trauma centers and motor vehicle accidents in the level I trauma center. Twenty-five percent of all patients with a calcaneal fracture admitted to a level trauma I center had an ISS above 15 (p<0.001). More concomitant and associated injuries were seen in this population (p<0.001), e.g. more concomitant spinal injuries were present in the level I trauma population, 29% vs. 2% (p<0.001). In 49% of the cases, the calcaneal fracture affected the talar surface of the calcaneus, respectively 56% and 47% in the level I and II centers. Isolated extra-articular calcaneal fractures are more often seen in the level II trauma centers in comparison to the level I center (40% vs. 23%, p<0.001).

Table 3 demonstrates that the treatment of Sanders II and III fractures did not differ between the two trauma level populations. The level I population had more often a severe displaced intra-articular fracture (Sanders type IV, p<0.001) and were more often operatively treated in comparison to the population in the level II centers (p<0.001).

CT-imaging	Treatment	Trauma level I*	Trauma level II*	Total*
Sanders type I	Operative	0 (0)	0 (0)	0 (0)
Sanders type II	Operative	7 (50)	25 (50)	32 (49)
	Missing	0 (0)	1 (0)	1 (5)
Sanders type III	Operative	9 (90)	21 (62)	30 (68)
	Missing	0 (0)	1 (3)	1 (2)
Sanders type IV†	Operative	10 (83)	4 (57)	14 (74)
	Missing	1 (8)	1 (14)	2 (11)
Isolated anterior surface fracture	Operative	0 (0)	1 (7)	1 (4)
Isolated extra-articular fracture	Operative	0 (0)	1 (4)	1 (3)
No CT-imaging available†	Operative	2 (13)	4 (4)	6 (6)
	Missing	2 (13)	1 (1)	3 (3)
* n=(percent within treatment per CT-imaging type); †=p<0.05				

Table 3: Differences in treatment per level of trauma.

Discussion

In this study we have evaluated patient, trauma and fracture characteristics in patients with a calcaneal fracture; moreover, these characteristics were compared between the different levels of trauma care in a regional inclusive trauma system. Knowledge on these matters could help in the interpretation of results from different trauma centers and might help to stimulate improvements in management of these fractures. The main finding in this study is that the level I population differed substantially in patient, and injury characteristics compared to the level II population.

Two previous studies examined demographics and injury characteristics in patients with a calcaneal fracture [4,17]. The Scottish study of Mitchell et al. reviewed the characteristics of patients with calcaneal fractures in a single institution [4]. Our study was more or less in line with their study; however, our study demonstrated that the female-male rate is slightly more equally distributed (1.5:1 *vs.* 2.4:1).

The large cohort study from Bohl et al. selected patients from a nationwide trauma databank in the USA (the American College of Surgeons National Trauma Data Bank [NTDB]) that prospectively collected patients that were admitted to a hospital [17]. Our study results differed substantially from their study. Our study showed less patients with a calcaneal fracture caused by a motor vehicle accident (Bohl's study 49% vs. this study 10%) and had less associated injuries. Furthermore, a greater proportion of our patients had an ISS score less than 16 (Bohl's study 76% *vs.* this study 94%). This difference could be explained by the inclusion criteria of this study and the inclusion criteria of the NTDB. We have included all patients who were diagnosed with a calcaneal fracture, thus also minor injured patients with an isolated calcaneal fracture who did not require an admission. In comparison to the NTDB, which only includes patient who are admitted to the hospital. The results from Bohl's study resembled more closely to the results from our level I population. Possibly, the difference is due to inclusion of patients that were admitted to the hospital that involved patients with a higher energy trauma; consequently, lead to more severely injured patients.

Spinal fractures are well-known concomitant injuries in patients who sustained a calcaneal fracture [18-22]. Previous studies reported a concomitant spinal fracture in 6% to 22% in these patients [18,20-22]. Our study also demonstrated a high percentage in the level I trauma population, this might suggest that additional imaging of the spine in a patient with a calcaneal fracture in a level I trauma center would be meaningful, also taken the mechanism of trauma into account.

The patients in the trauma level II population were significantly older; moreover, a substantial proportion was older than 70 years at the time of trauma. Recognition of this subgroup is valuable, because their optimal management might be different due to treatment and rehabilitations limitations caused by their comorbidities. Older patients are more likely to be treated conservatively if the long- term outcomes are expected to be similar; moreover, elderly are generally frail; thus, are more likely to develop complications, such as delirium, or remain bedridden that may cause pneumonia or other infections. These patients may benefit from geriatric physician consultation. In addition, a considerable number of the injuries occurred in the residential area or were the result of a simple fall. Prevention of these simple falls in the residential area might be beneficial in this subgroup.

This study further shows a significant difference between the numbers of patients treated operatively and conservatively in the level I versus II trauma centers. This could be due to the larger proportion of patients with extra-articular calcaneal fractures in the level II trauma population. The patients are more likely to be treated conservatively. We did not specifically evaluate this aspect because this study has a retrospective design and the reasoning for the chosen treatment is unfortunately in most cases non-traceable. More operatively treated patients in the level I population could be a consequence of the multiple injured origin in these patients in this center and the expected better outcome on the short term after surgery. Because, the rehabilitation and weight bearing exercises can start in an early stage. This has also been demonstrated in other trauma patients groups with extremity injuries [23]. Furthermore, Sanders type IV fractures were significantly more often treated operatively in the trauma level I population. Though, due to the small sample size, and the high rate of missings (>10%) the validity of such a statement could be subject of discussion. Furthermore, it would be interesting to evaluate the long term follow-up in these specific patients and study the differences.

The trauma level II population demonstrated to have substantially more isolated calcaneal fractures (low-complex). As demonstrated in the study of Van Laarhoven et al. clinical pathways might improve the outcome of these patients and reduce hospital length of stay [24]. Clinical pathways may contain early consultation of a rehabilitation physician and a physiotherapist. In the elderly it can be beneficial to have early geriatric consultation and a specialized combined geriatric medicine and traumatology ward [24]. In contrast, the level I population showed to have a higher heterogeneity in injuries which might not fit in a clinical pathway. However, a large proportion of the trauma level I population have a psychiatric history that may benefit from early involvement of a psychiatric nurse.

Alike most retrospective studies, data collection is limited by information that was not or incorrectly recorded. Missing data in our study was lower than 10%. CT-imaging was not performed in 36% of the cases. This could be explained by the fact that in these patients the conventional radiographs showed an extra-articular fracture and no other indication for an additional CT-image. In these patients CT-imaging is not required in the diagnostic process and only leads to unnecessary exposure to radiation and higher monetary costs. We have further performed a thorough search in three different databases to minimize the chance of missing patients who meet the inclusion criteria. Due to the regional design of the study, these results represent a reliable reflection from the demographics and trauma characteristics of patients with a calcaneal fracture in a trauma population and allow us to generalize the results to countries with similar demographics and economic welfare.

Conlusion

In conclusion, our study demonstrates, that there are remarkable differences between the level I and II trauma centers in the demographic patterns, injury and fracture characteristics of patients with a calcaneal fracture. These differences should be accounted for in the interpretation of results according to the level of trauma care provided in the particular trauma center. Additionally, in the trauma level II centers more low-complex calcaneal fractures and distinctively other subgroups, such as elderly, are admitted that might benefit from customized management. This customized management may involve, among other things, early consultation of a rehabilitation physician or a geriatric nurse.

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