Foot and Ankle Fractures at the Supination Line

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Abstract

Background: The supination line is a fictive line along the foot and ankle, on which over twenty fracture types and approximately ten different ligamentous sprain-injuries have been identified.

Objective: The current study was conducted to evaluate the incidence of different types of supination line injuries visible at the initial radiographs at the Emergency Department and to determine the type and percentage of misdiagnosed injuries.

Method: Retrospective study of consecutive patients who visited the Emergency Department, between January 1 and June 30, 2009, after sustaining an injury of the foot or ankle and had a radiograph taken within 24 hours of the incident.

Results: In the six-month study period 1,284 patients were included. In these cases the trauma mechanism was a sprain in 780 patients (60.7%). Of these patients 310 suffered from a fracture (40%). There were 36 (4.6%) false-positive cases and in 91 (11.7%) cases the initial diagnosis was false-negative. The number with a missed fracture expressed as a percentage of all patients with a fracture was 29.4 percent (91/310).

Conclusion: Detection of injuries along the supination line remains difficult. This study might aid in decreasing the number of misdiagnosed injuries, which is of value as these might negatively affect outcome.

Keywords: Supination line, sprain, ankle, foot, avulsion fractures

Introduction

Avulsion fractures of the foot or ankle occur in up to 15 percent of cases after a supination injury (1-4). These injuries occur at predetermined locations along the so called supination line. Traction injuries occur on the lateral side, whereas compression injuries can be found on the medial side. This was already described by Pouteau in 1783 and by Malgaigne in 1847 (5), but became more widely known after the publication of Hellpap in 1963 (6). However, few publications on the subject have been published since (2, 4, 7, 8).

Hellpap called the fictive line along which injuries from a sprain-trauma can be found 'the supination line' (Figure 1). More than twenty fracture types and approximately ten different ligamentous injuries have been identified along this supination line. These supination line injuries were further divided into three groups depending on traumamechanism and fracture-location (Lateral Line, Medial Line, and Transverse Line) by Dihlmann et al. (8). Table 1 shows an overview of the different sprain-injury types along the supination line reported in the literature. To date, two studies report on demographics and frequency of the various fracture types (2, 3) and two studies report on missed avulsion fractures in sprain injuries but do not specify per type (8, 9).

The current study was conducted to evaluate the incidence of different types of supination line injuries at the Emergency Department and to determine the type and percentage of injuries that were missed at first presentation.

Material and Method

This is a retrospective study of all consecutive patients, between January 1 and June 30, 2009, who visited the Emergency Department (ED) and had a radiograph taken within 24 hours after sustaining an injury of the foot or ankle.

Patient characteristics (i.e., age at trauma and gender), fracture characteristics (i.e., and type of fracture and affected side), and trauma mechanism (i.e., sprain injury, fall from height, falling object, stubbing, or other) were recorded from the electronic Emergency Department patient files and the picture archiving and communication system (PACS: Kodak Carestream© 2008). In order to determine the incidence of different types of supination line injuries only the patients with a sprain injury and a radiographic abnormality included. Multiple fractures in one patient were scored individually, except in those cases where they formed a single entity such as a Lisfranc fracture dislocation or a trimalleolar ankle fracture. All digital radiographs and radiographic reports were re-evaluated by two researchers (TS, ES). Any discrepancy between reviewer and radiographic report was settled by consensus of all authors. This data was used to compare with the patient files from the ED to determine whether an injury was missed at the radiograph.

Results

In the six-month study period 1,284 patients had one or more radiographs of their foot or ankle taken at the Emergency Department because of an acute trauma. There were 671 male (52.3%) and 613 female (47.7%) patients. The mean age was 30.7 years; male patients were on average 28.6 years compared with 33.1 years for female patients. The right side was injured 615 (47.9%) times. The trauma mechanism was a sprain in 780 cases (60.7%), 86 times a fall from height, 228 times a falling object on the foot, stubbing the foot occurred 109 times, 70 patients had a different trauma mechanism of which 33 were bicycle spoke injuries, and in 11 cases the trauma mechanism was unknown or could not be determined. In Table 2 the percentage of cases with a fracture per trauma mechanism is shown.

Table 3 shows the various fracture types occurring in patients with a sprain injury. The most frequently encountered injuries were Weber B type ankle fractures, fibular avulsion fractures, and proximal fifth metatarsal fractures. There were 36 (4.6%) false-positive cases, in which the physician at the ED incorrectly treated a patient for a fracture. In 91 (11.7%) cases the diagnosis was false-negative, in other words a fracture was missed (Table 3). The number of patients with a missed fracture expressed as a percentage of all patients with a fracture in the same location was 29.4 percent (91/310). Twenty-five (8.1%) patients had a second injury visible at their radiographs, mainly avulsion fractures, of which 21 were not reported in the patient records. Examples of missed injuries at the supination line are shown in Figure 2, 3 and 4.

Discussion

Sprain injuries caused 60.7 percent of all foot ankle injuries during the six-month study-period. Approximately 40 percent of these suffered from one or more fractures, of which two-thirds were avulsion fractures indicating severe ligamentous injuries.

The most frequently encountered fractures were Weber B type ankle fractures, fibular avulsion fractures, and proximal fifth metatarsal fractures. Similar injuries types and incidence rates were identified by Fallat et al(2). The higher total amount of fractures in this study differs from that by Fallat et al. and other studies because of the inclusion of all fractures after supination injury and not only the avulsion fractures. For example, ankle fractures represented 11% of all sprain injuries in this study.

Of all 1,284 patients 11 percent of fractures had been overlooked or misdiagnosed, which is almost 30 percent when calculated as percentage of total amount of patients with a fracture. In the literature the number of missed fractures expressed as a percentage of all fractures in the same location varies between 7.6 to 18% for foot and 2.8 to 21.7% for ankle injuries (10-15). Dihlmann re-examined 112 patients with a sprain-injury and found 96 (85.7%) bony lesions, of which 60 percent was not identified at first presentation (8). Well-known foot ankle injuries with high percentages of missed fractures are anterior process fracture of the calcaneus, lateral process (snowboarders) fractures of the talus, Chopart injuries and Lisfranc fracture dislocations, which are overlooked or misdiagnosed as ankle-sprains in up to 40% of the cases in the ED (16-21). For osteochondral lesions of the talus the percentage of missed injuries might even be as high as 50% (22). Physicians must have a high index of suspicion for these frequently overlooked injuries. Structured analysis of foot and ankle radiographs has been pointed out to aid in detecting obscure injuries (23). Using the supination line as a guideline for the structured evaluation of foot and ankle radiographs

might be a useful tool, as many of the missed and misdiagnosed injuries, will be along this virtual line.

A potential limitation of this study might be that the precise recollection of trauma mechanism is a problem for many patients. Up to 40 to 50 percent of patients are not able to provide an adequately description on the movement of the foot at the time of injury (1, 24). This might explain the presence of toe fractures in this series compared to other studies.

Several different radiographic projections have been introduced to visualize possible avulsion fractures of the anterior process (25), proximal fifth metatarsal (26), distal fibula (27), talar dome (28), posterior process of the talus (29), and talar neck (30, 31). However, especially in midfoot injuries the conventional x-rays are known to lead to a large percentage of missed injuries (32), which has resulted in an increase in CT-scanning in suspected foot and ankle injuries. Obviously, this will lead to an enormous increase in the detection of small (avulsion) fractures, with unclear clinical consequences. Several studies therefore question the need for additional radiographic views (33), because of the low rate of changes in therapeutic strategies. In the current study none of the missed injuries required surgery or alteration in treatment. Although this study does not take outcome into account, it is known from the literature that missed injuries can be the source of prolonged complaints (20). On the other hand the prognostic value of avulsion fractures of the distal fibula in ankle sprains is unclear (34). Fibular avulsion fractures, as seen on conventional anteroposterior or mortise view, might negatively affect outcome in contrast to avulsion fractures seen on additional views.

In conclusion, the number of missed foot and ankle injuries remains high. Many of these injuries occur along the supination line. Detection of these, mainly avulsion, fractures is

mandatory as they might influence outcome. The data as presented in this study may be valuable to decrease false-negative rates in the future.

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Conflict of Interest statement

No conflict of interest for any of the authors

Table 1. Literature overview of injuries marked as 'supination line injury'

Supination line injuries (distal to proximal)	Hellpap 1963	Weber 1966	Zeegers 1995	Fallat 1998	Mollenhoff 1999
Fifth metatarsal shaft fracture	X	X	X		
Fifth metatarsal proximal fracture	X	X	X	X	X
Lisfranc injury				X	
Cuboid (avulsion) fracture	X		X	X	X
Calcaneocuboid ligament injury		X			X
Navicular (avulsion) fracture		X	X	X	X
Sustentaculum tali fracture					X
Lateral calcaneal avulsion	X			X	
Anterior process calcaneus	X	X	X	X	X
Ext digitorum brevis avulsion					
Calcaneus tuber avulsion					X
Talar body fracture		X	X	X	X
Osteochondral lesion talus				X	
Lateral process talus			X	X	X
Posterior process talus				X	X
Dorsal talar neck avulsion				X	X
Medial talar avulsion				X	
Lateral malleolus (avulsion)			X	X	X
Medial malleolus (avulsion)				X	
Posterior malleolus					X

Table 2. Number of patients with a fracture per trauma mechanism

Trauma mechanism	Patients (N)	Cases with fracture (N)	Fracture rate (%)
Sprain (See table 3)	780	310	40
Fall from height	86	37	43
Object on foot	228	62	27
Stubbing	109	53	49
Rest	70	14	20
Unknown	11	2	18
Total	1,284	478	37

This table represents all patients during the six month study-period who had a radiograph taken at the ED for a foot and/or ankle injury. The sprain injuries are specified in Table 3.

Table 3. Fracture types encountered in patients with a sprain injury

Fracture type	Total (N)	Percentage of all sprain cases	Percentage missed fractures
Weber B	61	7.8	1.6
Lateral malleolus avulsion	45	5.8	40
MT5 proximal/avulsion	32	4.1	25
Anterior process calcaneus	17	2.2	88.2
Navicular body or avulsion	16	2.1	68.9
Weber C	15	1.9	0
Dorsal talar neck avulsion	11	1.4	63.6
Medial malleolus avulsion	11	1.4	63.6
Cuboid body or avulsion	11	1.4	72.7
Weber A	10	1.3	10
Toe fractures	9	1.2	33.3
MT1,2,3,or 4	8	1.0	0
Multiple MT	8	1.0	0
Lateral (process) talus avulsion	7	0.9	42.9
MT5 Jones	7	0.9	42.9
MT5 distal	6	0.8	33.3
Osteochondral lesion talus	6	0.8	66.7
Lisfranc fracture-dislocation	6	0.8	0 *
Medial mallolus	5	0.6	0
Distal tibia	5	0.6	0
SH-2 lat malleolus	4	.5	50
Ext dig brevis avulsion	4	0.5	100
Distal crural	4	0.5	0
Cuneiform complete or avulsion	4	0.5	75
Medial talar avulsion	4	0.5	75
SH-1 lat malleolus	3	0.4	33.3
Calcaneal tuber avulsion	3	0.4	0
MT5 shaft	3	0.4	0

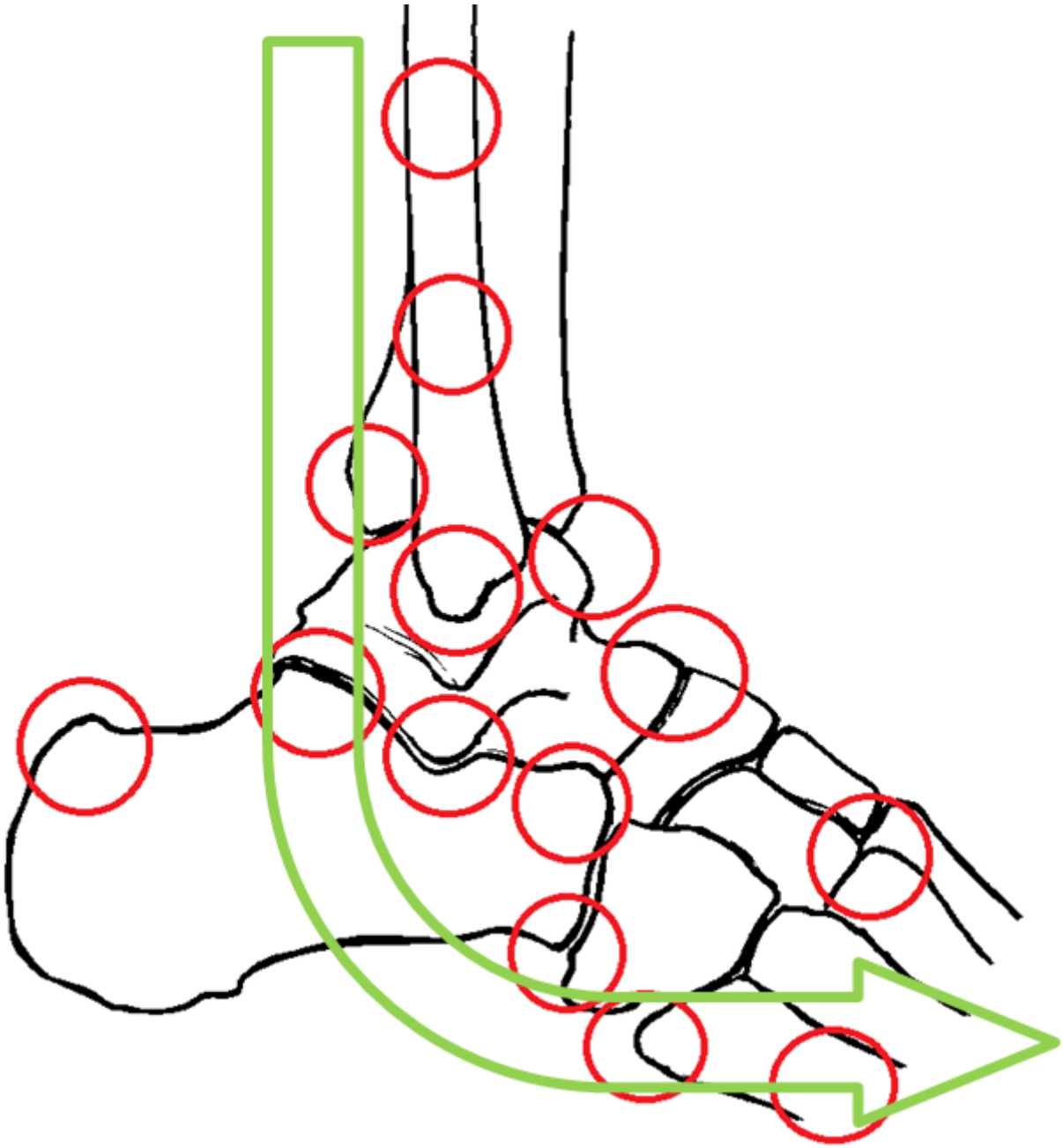
Posterior malleolus	2	0.3	0
Calcaneocuboid ligament injury	2	0.3	100
Calcaneal	2	0.3	0
Lateral process calcaneus	1	0.1	100
Sustentaculum tali	1	0.1	100
Chopart fracture-dislocation	1	0.1	0

The various fracture types are ranked from highest to lowest rate of occurrence

MT, metatarsal; SH. Salter-Harris classification type

*. Injuries were detected in all, but not labelled as a Lisfranc fracture-dislocation in 75%

Figure 1. A graphical representation of the supination line



The Supination line (Green arrow) is a fictive line along which various sprain-injuries (Red circles) can occur.

Figure 2. Misdiagnosed calcaneal injuries at the supination line

a, anterior process fracture calcaneus; b, calcaneocuboid ligamentous injury; c, sustentaculum tali fracture; d, anterior process fracture calcaneus

Figure 3. Misdiagnosed midfoot injuries at the supination line

a, the fracture at the second metatarsal was noted, however the cuboid fracture, indicating a Lisfranc injury, was missed; b, cuboid body fracture; c, navicular avulsion fracture; d, navicular fracture

Figure 4. Misdiagnosed talar injuries at the supination line

a, osteochondral lesion talus; b, talar head avulsion fracture; c, osteochondral lesion talus; d, lateral process fracture talus