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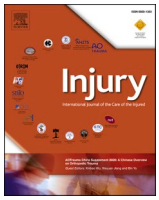

Epidemiology, classification, and treatment of 2084 Lisfranc injuries: An observational study from the Swedish fracture register

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ABSTRACT

Background: Lisfranc injuries are potentially severe but relatively uncommon. Limited epidemiological data regarding Lisfranc injuries of the midfoot are available. This study aimed to describe the injury's epidemiology, injury mechanism, and primary treatment.
Methods: An observational register study examined all Lisfranc injuries registered in the Swedish Fracture Register from 2013 to 2022. Data on sex, age, date of injury, injury type, injury mechanism, and primary treatment were analysed.
Results: Some 2084 Lisfranc injuries in 2079 patients (54 % men) were included in the study. The mean age at injury was 43 (18–92, SD 17.3) years for men and 49 (18–96, SD 17.4) for women. One of five cases were caused by high-energy trauma, and the most common injury mechanism was a simple fall - tripping (31 %). Approximately 39 % of patients underwent operative treatment, with fixation using plates (51 %) being the prevailing choice of treatment. Primary arthrodesis was performed in 11 % of the operatively treated cases.
Conclusions: Lisfranc injuries are the consequence of a broad spectrum of injury mechanisms, are primarily induced by low-energy trauma and found in all age groups in adults. The majority of Lisfranc injuries are treated non-operatively. This comprehension can aid in accurate diagnosis and management in everyday clinical practice.

Introduction

Lisfranc's joint forms the transition between the cuboid and the cuneiform bones proximal, together with the metatarsal bones distally and functions as a common joint complex [1]. Its anatomical shape keeps it stable with a vault formed by the triangular second and third TMT joints (tarsometatarsal), particularly the mortise formed by the more proximal TMT 2 joint [1]. In addition, the joint is stabilised by a capsule and ligament complex, which are generally stronger in the plantar than in the dorsal. The strong plantar and interosseous ligaments between the medial cuneiform and the second metatarsal are especially important for stability [1,2].

Injuries affecting the Lisfranc's joint have shown a range of severity, from subtle ligamentous injuries that may not be visible on standard radiographs to severe intra-articular fractures with malalignments or complete dislocations. Operative intervention has been proposed for displaced or unstable injuries and non-operative intervention has been reserved for stable injuries [3].

Lisfranc injuries are relatively uncommon, with a reported incidence of 1 case per 55,000 person-years, accounting for about 0.2 % of all fractures [4]. However, two recent investigations, albeit with limited geographical scope, have described the injury as more common (9 cases in one study and 14 cases per 100,000 person-years in the other study) [5,6]. Usually, the occurrence of the Lisfranc injury has been reported as the result of high-energy trauma (e.g., traffic accidents, falls from heights, or crush injuries) and the most affected patients in these instances were typically younger men. [4,7–11]. Conversely, recent studies suggest that high-energy trauma contributes only to a smaller portion of the cases [5,6].

This study aimed to describe the epidemiology of Lisfranc injuries by analysing age and sex distribution, injury mechanism, fracture classification, annual and weekly variation, as well as primary treatment choice using data from the Swedish Fracture Register (SFR).

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Methods and materials

Study design and setting

We used prospectively collected data derived from the SFR for this observational register study.

The SFR was initiated in 2011. The register is a non-mandatory national quality register for managing fractures and their treatment. The SFR collects data on injury mechanisms, fracture characteristics, and fracture treatment by the treating physician using a web-based digital module. During registration, the physician registering is guided by information panels. For example, high-energy injuries are defined in the guidance as high-speed road accidents, cycling accidents at speeds above 35 km/h, falls from height and workplace accidents with crushing injuries. In the SFR, only patients with a permanent Swedish personal identity number and fractures that occurred in Sweden are registered. [12,13]. The study period saw an increase in the coverage and completeness of SFR registrations, as more orthopaedic and trauma departments in Sweden began participating in the register and collecting data. In 2014, half of the 54 orthopaedic departments in Sweden treating fractures were engaged, and in 2021, 100 % coverage was reached [13]. Most departments reach completeness for different fracture types, ranging from 70 % to 90 %. In 2020, the completeness in the register was 85 % for hip fractures and 70 % for wrist fractures [13]. National completeness of 51 % for foot fractures was reported in 2021, with some departments reaching a completeness of over 90 % [14]. At the beginning of 2024, over 910,000 fractures were registered in the SFR. Multiple studies have shown a high accuracy and validity of SFR data [13, 15–20].

Patient selection

All patients ≥18 years old registered in the SFR with a Lisfranc injury (85 C1-C4) between January 2013 and December 2022 were included in the study.

Outcome variables

For the study, we used data from the SFR on sex, age, date of injury, injury mechanism, trauma energy (low or high), fracture class, and initial treatment. Age of the patients was categorised into 18–20 years, groups of ten years and 81 or older. The injury mechanism was grouped into six categories: simple falls, falls from other levels, mechanical force, living force, traffic/transport accidents, and other causes. The SFR classifies Lisfranc injuries into four groups (85-C1 to 85-C4, Fig. 1). For the group 85-C1, there are only ligament injuries. The other groups are classified depending on fracture occurrence: fractures of the proximal row (85-C2), distal row (85-C3), or on both sides (85-C4) of the TMT joints. Primary treatment was categorised into non-operative and operative approaches. Operative treatment was further grouped into osteosynthesis with plates, K-wires, screws, combined methods, primary arthrodesis, and other methods.

Statistics

Categorical variables were presented as frequencies or proportions and continuous variables as means with standard deviations, and ranges. All data analyses and statistical calculations were performed using IBM SPSS Statistics version 27.0.

Results

Descriptive data and patients

Some 2084 cases of Lisfranc injury were documented in 2079 patients. Three patients had bilateral injuries, and two had an additional Lisfranc injury later in the study. About 54 % ($n = 1131$) of patients were male. The data on fracture distribution showed a peak among men aged 21–30 and women aged 51–60 (Fig. 2). The mean age at injury was 43 (18–92, SD 17.3) years for men and 49 (18–96, SD 17.4) years for women.

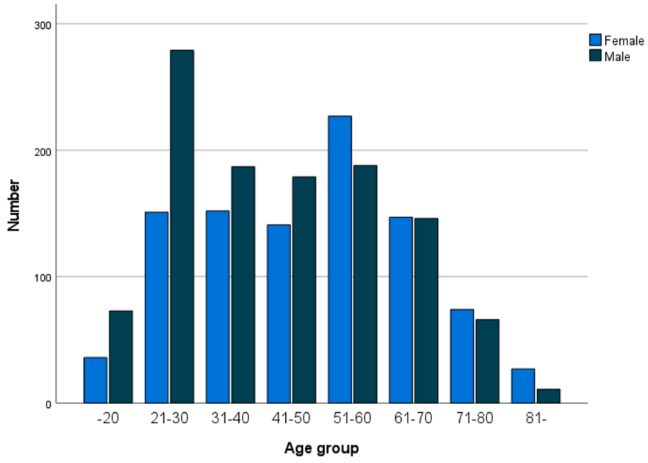

Fig. 2. Distribution of Lisfranc injuries by age group and sex.

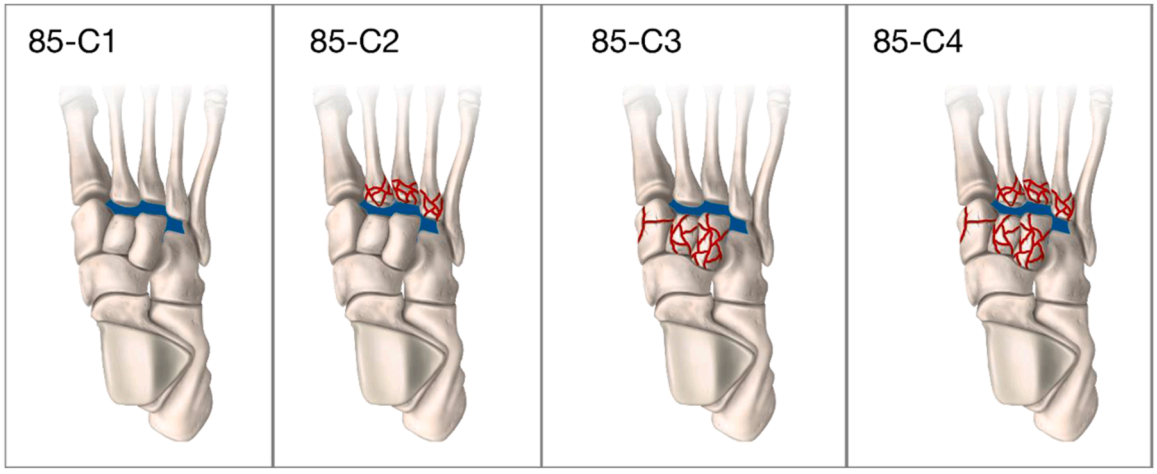

Fig. 1. Classification of Lisfranc injuries used in the SFR. 85-C1 to 85-C4 correspond to Lisfranc injuries with ligamentous damage only, with fractures proximal to the joint, distal to the joint or on each side.

Injury mechanism

The two most common subgroups of injury mechanism were simple falls - tripping (31 %) and falls other levels - from stairs (10 %) (Table 1). The occurrence of low-energy trauma was recorded in 60 % of cases and high-energy trauma in 20 %. High-energy trauma was most common in injuries of traffic/transport acccidents and mechanical force (Table 1). High-energy trauma as a cause was also reported considerably more often in males than in females in all age groups (Fig 3).

A simple fall was the most common injury mechanism in all classes of Lisfranc injuries. Although the distribution of classes of Lisfranc injuries was generally comparable among the different of injury mechanisms, there were distinct variations observed in the case of traffic accidents. Among the injuries observed in this group, particularly class C3 injuries were found to be more common than ligament injuries alone, accounting for 20 % and 10 %, respectively (Table 2).

Annual and weekly variation

A higher proportion of Lisfranc injuries occurred during the summer. In the summer months of June to August, 33 % of cases were observed compared to 21 % in the winter months of December to February. The highest number of cases occurred in June (12 %) and the lowest in February (6 %) (Fig. 4). It is also slightly more common for injuries to occur at the end of the week. The highest number of cases (21 %) was seen on Saturdays (Fig. 4). Operative treatment of Lisfranc injuries is almost entirely carried out on weekdays (Fig. 5).

The distribution of injury mechanisms throughout the year shows that the three major causes, considerably increase during the summer. Traffic accidents and falls from other levels peak in July. Simple falls also peak during the summer but is characterised by a bimodal distribution with another peak in the winter. Other injury mechanisms have a more even distribution throughout the year (Fig. 6).

Associated fractures

In the 2079 patients with Lisfranc injuries, 954 associated fractures were registered among 27 % ($n = 562$) of the patients. 20 % ($n = 187$) of these associated fractures were seen in the mid and hindfoot and 19 % ($n = 183$) in the forefoot. Furthermore, 16 % ($n = 156$) occurred in the ankle, 14 % ($n = 138$) in the remaining lower limb, 8 % ($n = 73$) in the vertebral column or pelvis and 23 % ($n = 217$) in the hand, upper limb or shoulder. Of the associated foot fractures, 79 % ($n = 291$) were ipsilateral. In a similar way, 72 % ($n = 211$) of associated fractures of the lower limb (excluding the foot) and 53 % ($n = 116$) of those of the upper limb were ipsilateral.

Classification and method of treatment

About 2 % ($n = 33$) of the cases were reported as open injuries. Lisfranc injuries with only ligamentous injuries, i.e. without fractures (85-C1), represented 6 % of all cases. In 50 % of cases fractures were only distal to the joint (85-C2), in 10 % only proximal (85-C3), and in 33 % on both sides (85-C4) of the Lisfranc's joint. Broken down by age and sex, it can be seen that in women, 85-C4 injuries are slightly more common in the younger and older age groups than in the 31 to 70 age group. In men, it was slightly the contrary and these were seen more frequently between the ages of 31 and 60 (Fig 7).

Of the total injuries, 55 % ($n = 1151$) were managed through non-operative treatment, 39 % ($n = 823$) required some form of opeative intervention, and 5 % ($n = 110$) had missing treatment data. The proportion of operatively treated fractures varied from 37 to 60 % across the different classifications of Lisfranc injuries (Table 2). High-energy injuries were treated operatively more frequent than low-energy injuries (Table 3). Of those treated operatively 51 % ($n = 418$) were operated with plate fixation, 9 % ($n = 75$) with K-wires, 7 % ($n = 56$) with screws, and a primary arthrodesis was performed in 11 % ($n = 92$). A combination of methods was reported in 15 % ($n = 127$) of the operatively treated patients.

Discussion

In this nationwide register-based observational cohort study Lisfranc injuries were caused by a wide range of injury mechanisms but mostly by low-energy trauma. Lisfranc injuries peak in men aged 21–30 years and in women aged 51–60 years, with most of these injuries treated non-operatively.

In comparison with other common fracture groups, such as ankle (5 %) or distal radius (5 %), Lisfranc injuries (20 %) are caused by a substantially higher proportion of high-energy trauma [21,22]. However, these still constitute a minority and, in comparison, are considerably lower than, for example, talar fractures (35 %) [23]. In the present study simple falls are the most common cause of injury and are more than twice as common as traffic accidents.

The distribution by age and sex also shows a pattern intermediate between the ankle and the talar fractures. The talus fracture,

Table 1
Demographics of 2084 Lisfranc injuries in the Swedish Fracture Register. Distribution (n (%)) of different groups and most common subgroups of injury mechanisms divided by trauma energy (high, low or unknown).

Injury mechanism	High-energy	Low-energy	Unknown[a]	All
Simple falls	10 (1 %)	664 (84 %)	112 (14 %)	786 (38 %)
– Tripping	3 (0.5 %)	547 (85 %)	95 (15 %)	645 (31 %)
– Slipping ice/snow	2 (3 %)	49 (84 %)	7 (12 %)	58 (3 %)
Falls other levels	117 (26 %)	256 (56 %)	84 (18 %)	457 (22 %)
– Stairs	8 (4 %)	157 (78 %)	37 (18 %)	202 (10 %)
– Unspecified	18 (28 %)	37 (58 %)	9 (14 %)	64 (3 %)
– Ladder	31 (48 %)	20 (31 %)	13 (20 %)	64 (3 %)
Mechanical force	91 (41 %)	86 (39 %)	45 (20 %)	222 (11 %)
– Trapped between objects	39 (49 %)	25 (31 %)	16 (20 %)	80 (4 %)
– Falling objects	27 (35 %)	29 (38 %)	20 (26 %)	76 (4 %)
Living force	11 (13 %)	51 (62 %)	20 (24 %)	82 (4 %)
– Hit by/hit another person	2 (5 %)	31 (72 %)	10 (23 %)	43 (2 %)
Traffic/transport accident	177 (54 %)	106 (32 %)	44 (13 %)	327 (16 %)
– Cyclist – falls, not collisions	9 (16 %)	33 (57 %)	16 (28 %)	58 (3 %)
– Motorcyclist – falls, not collisions	33 (70 %)	7 (15 %)	7 (15 %)	47 (2 %)
Other/unspecified	8 (6 %)	79 (59 %)	46 (35 %)	133 (6 %)
Missing	4 (5 %)	13 (17 %)	60 (78 %)	77 (4 %)
Total	418 (20 %)	1255 (60 %)	411 (20 %)	2084 (100 %)

[a] missing, unknown or not applicable due to injury mechanism.

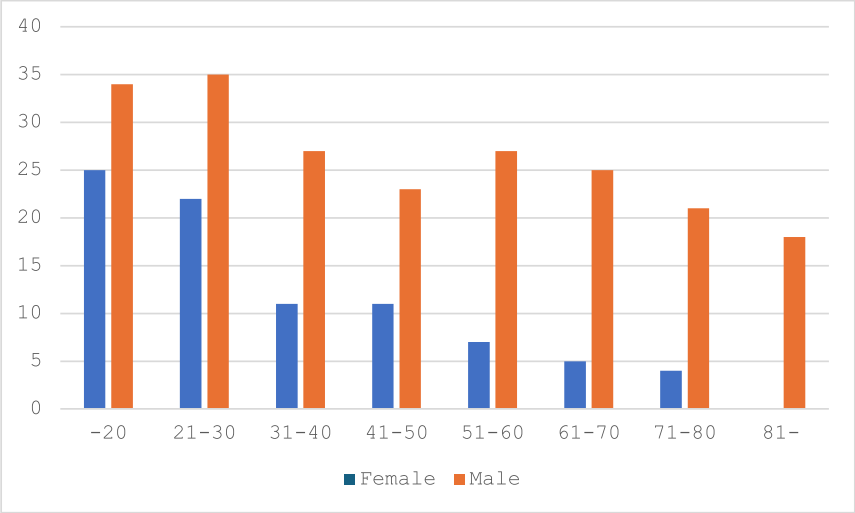

Fig. 3. Proportion (%) of high-energy trauma as cause of Lisfranc injury divided by age and sex.

Table 2
Patient characteristics of 2084 Lisfranc injuries in the Swedish Fracture Register (SFR) including trauma energy, injury mechanism, and treatment divided by Lisfranc injury class.

Lisfranc injury classification in SFR	85-C1 *n* = 131	85-C2 *n* = 1051	85-C3 *n* = 210	85-C4 *n* = 692
Age	43.2 (16.8)	46.2 (17.5)	43.6 (17.5)	46.3 (17.5)
Male	71 (54 %)	548 (52 %)	123 (59 %)	389 (56 %)
Open injury	0 (0 %)	9 (0.9 %)	1 (0.5 %)	23 (3 %)
Trauma energy				
Low-energy	81 (62 %)	643 (61 %)	125 (60 %)	406 (59 %)
High-energy	19 (15 %)	178 (17 %)	47 (22 %)	174 (25 %)
Unknown[a]	31 (24 %)	230 (22 %)	38 (18 %)	112 (16 %)
Injury mechanism				
Simple falls	47 (36 %)	424 (40 %)	76 (36 %)	239 (35 %)
Falls other levels[b]	36 (27 %)	215 (20 %)	36 (17 %)	170 (25 %)
Mechanical force[c]	12 (9 %)	100 (10 %)	26 (12 %)	84 (12 %)
Living force[d]	4 (3 %)	45 (4 %)	11 (5 %)	22 (3 %)
Traffic/transport accident	13 (10 %)	150 (14 %)	43 (20 %)	121 (18 %)
Other	11 (8 %)	70 (7 %)	12 (6 %)	40 (6 %)
Missing	8 (6 %)	47 (5 %)	6 (3 %)	16 (2 %)
Treatment				
Non-operative	50 (38 %)	608 (58 %)	108 (51 %)	385 (56 %)
Operative	78 (60 %)	390 (37 %)	94 (45 %)	261 (38 %)
Missing	3 (2 %)	53 (5 %)	8 (4 %)	46 (7 %)

[a] missing, unknown or not applicable due to injury mechanism.
[b] ladders, stairs, scaffolding, playground facilities, heights, etc.
[c] trapped between objects, hit by falling objects, power transfer devices, tools, machinery, etc.
[d] trapped in a crowd, hitting or being hit by another person, etc.

characterised by high-energy injury, exhibits a primary peak among male and female individuals aged 20–30 [23]. Conversely, ankle fractures with low-energy injury are more prevalent among women in the upper middle age group [24]. In the present study we report a peak in Lisfranc's injuries in men at their 20 s and a peak in women at their 50s. This observation is probably an effect of the widespread injury mechanisms, with more high-energy injuries in younger men and simple low-energy falls more common in women.

The Lisfranc injury shows a higher prevalence during the summer months, in contrast to the annual fluctuation observed in ankle fractures, but demonstrates similarities with talar fractures [22,23]. All three major groups of injury mechanisms behind the Lisfranc injury, increase during the summer. Some relatively common causes such as bicycle and motorbike accidents are, of course, much more typical during the summer in a Swedish perspective with distinct seasons. Many other activities probably also follow this pattern. Apart from the obvious change in activity and activity patterns, a possible explanation for the increase could be that barefoot walking in summer or wearing lighter summer footwear may render the midfoot more susceptible to injuries. This hypothesis is supported by the sharp increase in simple falls during the summer. Ankle fractures on the other hand are mainly caused under slippery conditions with shoes on (e.g., in winter conditions on icy sidewalks). Simple falls, unlike falls from other levels and traffic accidents, show a bimodal pattern with also a mid-winter peak. Slipping on icy ground may not be the most frequent cause, but it still accounts for a few per cent of injuries. The distribution over the week reveals a slight increase towards the end of the week, which could also be attributed to the population's pattern of activity and is consistent with other fractures [21,22,24].

Opertive interventions for these injuries are predominantly performed on weekdays, reflecting the sub-acute approach to their management. The need for further visualisation with computed tomography, optimising soft tissue conditions by reducing swelling, and scheduling an experienced surgeon could contribute to this pattern.

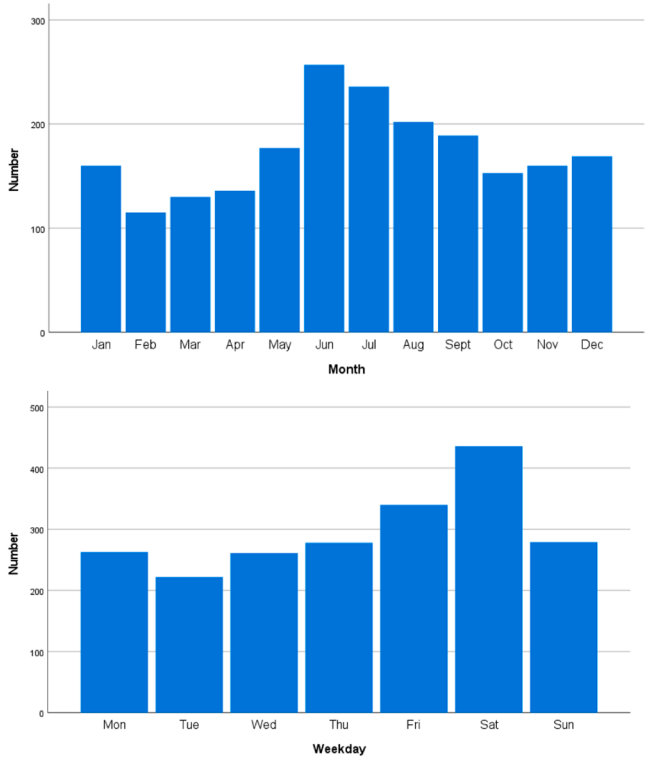

Fig. 4. Monthly and weekly distribution of 2084 Lisfranc injuries.

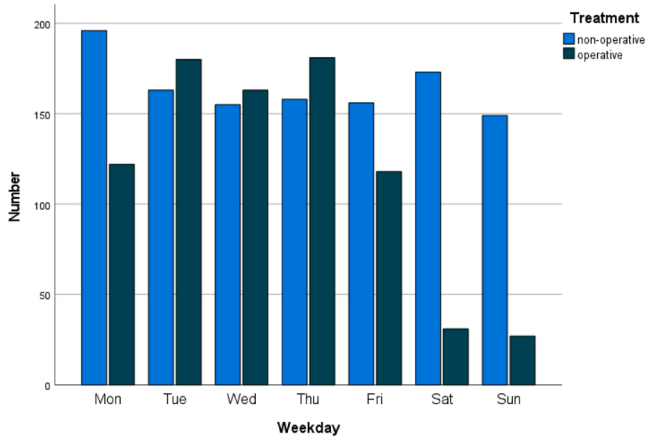

Fig. 5. Distribution of the day of the week on which operative and non-operative treatment was initiated for 2084 Lisfranc injuries, regardless of when the injury occurred.

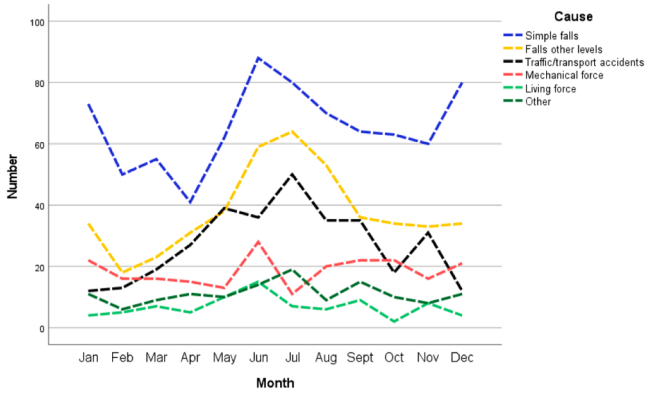

Fig. 6. Distribution and frequency of different injury mechanisms throughout the year.

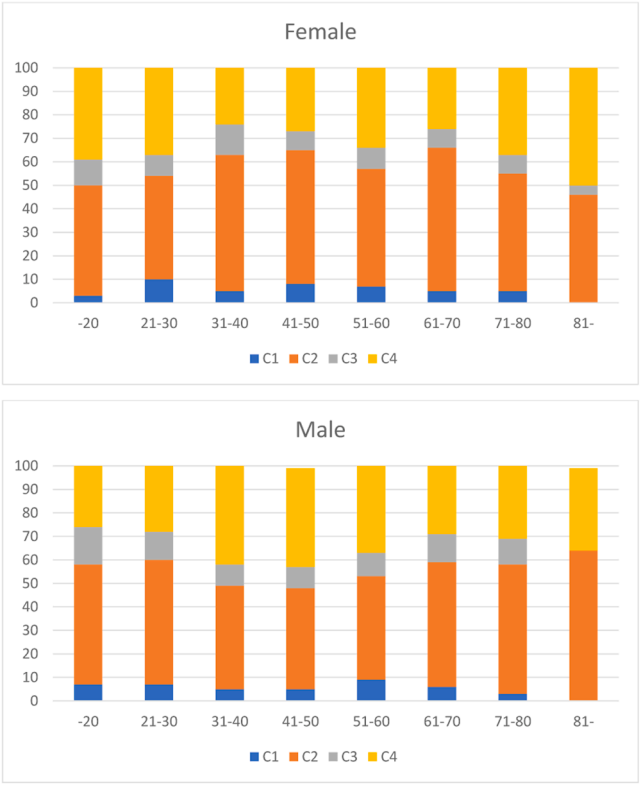

Fig. 7. Distribution of classes of Lisfranc injuries in women and men divided by age.

Table 3
Treatment of 2084 Lisfranc injuries according to whether the injury is characterised as being caused by a high or low energy mechanism.

	Low-Energy $n = 1255$	High-energy $n = 418$	Unknown[a] $n = 411$
Treatment			
Non-operative	735 (59 %)	170 (41 %)	246 (60 %)
Operative	468 (37 %)	220 (53 %)	135 (33 %)
Missing	52 (4 %)	28 (7 %)	30 (8 %)

[a] missing, unknown or not applicable due to injury mechanism.

The study reinforces the more recent view [5,6] that Lisfranc injuries are not primarily high-energy injuries, as has been reported in the past [4]. Possible explanations for this could be the demographic change seen in many countries, i.e. ankle fractures have increased with the ageing population [25]. Consequently, the incidence and the panorama of Lisfranc injuries are likely to be affected. The second and in our opinion more important reason is the improved technical possibilities routinely used to diagnose and visualise injuries in the midfoot with CT. The Lisfranc joint is anatomically complex and discrete injuries are difficult to detect on conventional radiographs [26].

The information on epidemiology and treatment traditions from a large dataset at national level for a rare injury can guide both day-to-day clinical management and decision-making for healthcare stakeholders.

To our knowledge, this is the first nationwide study describing the panorama of Lisfranc injuries. Using data derived from a national quality register with registration and classification of fractures regularly entered by the treating physician enables a more detailed description of the demographics, injury, fracture classification, and treatment. The classification of Lisfranc injuries in the SFR allows a description of the injured midfoot bones but cannot discriminate between stable and

unstable injuries. A limitation of the SFR is the lack of a more detailed and validated classification of this complex injury. Given the stepwise introduction and the present completeness of the SFR, we cannot identify the overall incidence of Lisfranc injuries [13]. The retrospective study design and inherited limitations of register-based studies, such as miscoding, under-reporting, and missing data, are inherent limitations.

To summarise, Lisfranc injuries are the consequence of a broad spectrum of injury mechanisms, are primarily induced by low-energy trauma and found in all age groups in adults. The majority of Lisfranc injuries are treated non-operatively. This comprehension can aid in accurate diagnosis and management in everyday clinical practice.

Level of evidence: IV, retrospective observational cohort study.

Abbreviations

SFR - Swedish Fracture Register
TMT - Tarsometatarsal

Ethics

The study was approved by the Swedish Ethical Review Authority (dnr 2023–01250–01) and complied with the 2013 Helsinki Convention on Medical Research. The data in the Swedish fracture register are gathered per an opt-out principle. Because this study solely relied on register data, the Ethical Review Authority determined that contacting each individual in the registers was unnecessary and thus waived the requirement for individual consent.

CRediT authorship contribution statement

Hans Juto: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Sebastian Mukka:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **Olof Wolf:** Writing – review & editing, Methodology, Conceptualization. **Michael Möller:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

The authors declare no competing interests related to the present study.

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