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Demographics, mechanism of injury, and associated injuries of 25,615 patients with talus fractures in the National Trauma Data Bank

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ABSTRACT

Background: Extensive research has been conducted concerning the epidemiology of fractures of the calcaneus and ankle. However, less work has characterized the population sustaining talus fractures, necessitating the analysis of a large, national sample to assess the presentation of this important injury.
Methods: The current study included adult patients from the 2011 through 2015 National Trauma Data Bank (NTDB) who had talus fractures. Modified Charlson Comorbidity Index (CCI), mechanism of injury (MOI), Injury Severity Score (ISS), and associated injuries were evaluated.
Results: Out of 25,615 talus fracture patients, 15,607 (61%) were males. The age distribution showed a general decline in frequency as age increased after a peak incidence at 21 years of age. As expected, CCI increased as age increased. The mechanism of injury analysis showed a decline in motor vehicle accidents (MVAs) and an increase in falls as age increased. ISS was generally higher for MVAs compared to falls and other injuries.
Overall, 89% of patients with a talus fracture had an associated injury. Among associated bony injuries, non-talus lower extremity fractures were common, with ankle fractures (noted in 42.7%) and calcaneus fractures (noted in 27.8%) being the most notable. The most common associated internal organ injuries were lung (noted in 19.0%) and intracranial injuries (noted in 14.9%).
Conclusion: This large cohort of patients with talus fractures defined the demographics of those who sustain this injury and demonstrated ankle and calcaneus fractures to be the most commonly associated injuries. Other associated orthopaedic and non-orthopaedic injuries were also defined. In fact, the incidence of associated lumbar spine fracture was similar to that seen for calcaneus fractures (14%) and nearly 1 in 5 patients had a thoracic organ injury. Clinicians need to maintain a high suspicion for such associated injuries for those who present with talus fractures.
Level of Evidence: Level II, retrospective study

1. Introduction

Understanding injury patterns is useful for physicians, especially for orthopaedic surgeons, as it allows them to directly evaluate areas of likely injury once a primary injury is identified. Especially with distracting injuries, multiple surveys of the trauma patients and focused workups are critical.[1]

There are many examples of defined injury associations that help guide clinical management. Worsham et al. analyzed 62 patients with an open calcaneus fracture and were able to inform practitioners about the high percentages of local injuries (23% having an ipsilateral ankle fracture and 19% having a talus fracture) as well as distant trauma (24% of patients had upper extremity fracture and 15% of patients had spinal fractures).[2] Moreover, lumbar spine injuries have been noted to occur with calcaneus fractures,[3] scapular fractures have been shown to be associated with thoracic injuries,[4] and ipsilateral fractures of the femoral neck and shaft have been demonstrated as well.[5]

Talus fractures are often caused by high-energy impacts,

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classically with forced dorsiflexion of the foot. If not recognized and treated properly, talus injuries can cause foot deformities, lead to chronic pain, and interfere with walking.[6] With the above said, talus fractures are relatively uncommon (comprising less than 1% of all fractures), which can limit the size of the patient populations that are available for study.[7]

Several cohort studies have assessed the epidemiology of talus injuries. Elgafy et al. examined the incidence and pattern of 58 patients with talar fractures that were collected from two level I trauma centers and found that 86% of patients had multiple injuries.[8] Furthermore, Kirkpatrick et al. examined injuries from 12 Colorado ski resorts for 7 years and found that 2.3% of all snowboarding injuries were fractures of the lateral process of the talus.[9]

Despite the well-defined demographic and associated injury patterns of other orthopaedic injuries, such data is not as robust for talus fractures. The current study was thus defined to explore such considerations in a large nationwide sample. The National Trauma Data Bank (NTDB),[10] which was created by the American College of Surgeons to be a source of trauma related data collected voluntarily from trauma centers, was utilized for this purpose.

2. Methods

The NTDB is the largest multi-center trauma database in the country, containing information from over 900 trauma centers.[10] The following inclusion criteria were used on the NTDB to select patients for this study: (1) adult patients (over age 18) who were admitted to the hospital between years 2011 and 2015, and (2) an International Classification of Disease (ICD), 9th Revision code for either closed or open talus fractures (825.21, 825.31).

Table 1
Distribution of patients by age and sex.

Age	Male	Female	Total
18–39	8619	4856	13,475
40–65	6100	3685	9785
65+	888	1467	2355
Total	15,607	10,008	25,615

For the years studied, NTDB contains ICD-9 codes and chart-abstracted data. The variables used in this study were age, comorbidities, injury severity score (ISS),[10,11] mechanism of injury, and associated injuries (as defined by ICD-9 codes).

The following comorbidities were abstracted: hypertension, alcoholism, diabetes, respiratory disease, obesity, congestive heart failure, coronary artery disease, prior cerebrovascular accident, liver disease, functionally dependent status, cancer, renal disease dementia, and peripheral vascular disease. From these, a modified Charlson Comorbidity Index (CCI), a measure of overall comorbidity burden, was computed, as previously described.[12]

Patients were categorized into “fall”, motor vehicle accident (“MVA”), or “other” for mechanism of injury. Patients with a fall mechanism of injury were determined based on the following ICD-9 e-code ranges: 880.00–889.99, 833.00–835.99, 844.7, 881, 882, 917.5, 957.00–957.99, 968.1, 987.00–987.99. For MVA mechanism of injury, the following ICD-9 e-code ranges were used: 800–826, 829–830, 840–845, 958.5, and 988.5. Motor vehicle drivers, motorcyclists, bicyclists, and pedestrians were included in this category. All other e-codes were counted as “other”. Associated bony and internal organ injuries were identified by diagnosis codes as shown in Appendices 1 and 2.

The associated injury shadings on the skeleton and internal organ figures were created using Adobe® Photoshop® CS3. Increasing injury frequency is noted by darker shades on the grayscale images. Stata® 13.0 statistical software (StataCorp LP, College Station, TX), specifically the “tabulate” function for quantification, was used for all statistical analyses.

3. Results

3.1. Patient demographics

A total of 25,615 patients (15,607 males and 10,008 females) who had talus fractures and were over 18 years old were identified in the NTDB (Table 1). Fig. 1 shows the distribution of these patients by age. There is a general decline in incidence of talus fractures with increasing age, although there are local peaks at around ages 21 and

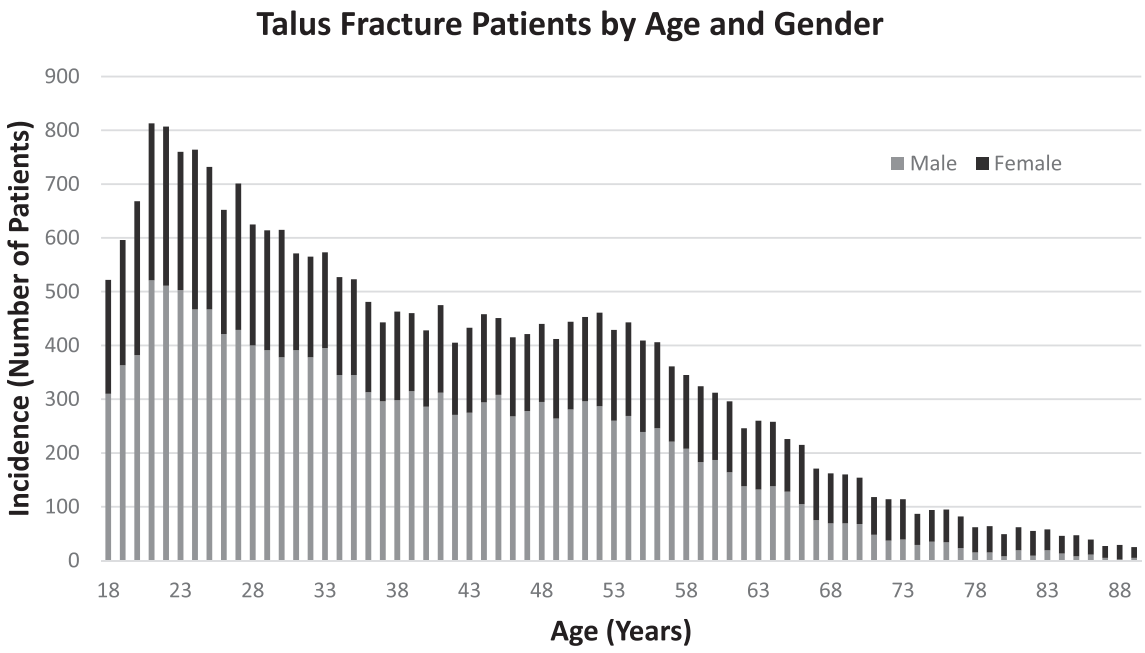

Fig. 1. Distribution of ages of all talus fracture patients by gender.

Table 2
Distribution of modified Charlson Comorbidity Index (CCI) by Age.

CCI	Age			
	18–39	40–64	65+	Total
0	12,606	387	0	12,993
1	798	3756	0	4554
2	48	3550	0	3598
3	10	1482	714	2206
4	3	381	1051	1435
>=5	10	229	590	829
Total	13,475	9785	2355	25,615

Note: Median values are underlined in each column.

Table 3
Distribution of injury severity score (ISS) by Age.

ISS	Age			
	18–39	40–64	65+	Total
0–9	7285	5280	1199	13,764
10–19	3380	2617	637	6634
20–29	1887	1331	388	3606
30+	923	557	131	1611
Total	13,475	9785	2355	25,615

Note: Median values are underlined in each column.

52. Most patients were below 65 years of age, with only 2355 patients (9.2%) who were older than 65. Of the 25,615 patients, 20,934 (81.7%) had closed fractures, while 4681 (18.3%) had open fractures.

3.2. Comorbidity index and injury severity

Table 2 shows modified Charlson Comorbidity Index (CCI) for age categories 18–39, 40–64, and 65+. The medians were 0, 2, and 4, respectively.

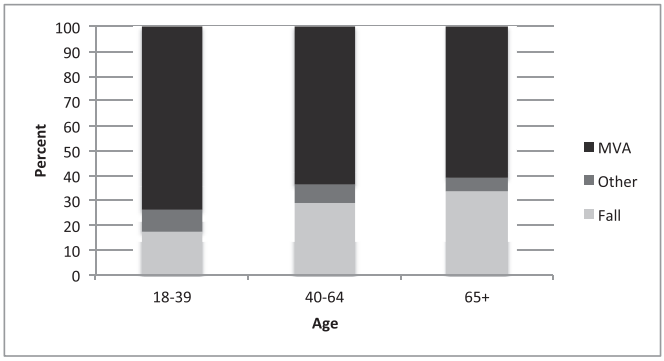

Fig. 2. Mechanism of Injury distribution of talus fracture patients by age.

Table 4
Distribution of injury severity score (ISS) by Mechanism of injury (MOI).

ISS	MOI			
	Fall	MVA	Other	Total
0–9	4698	7559	1507	13,764
10–19	881	5408	345	6634
20–29	282	3191	133	3606
30+	106	1448	57	1611
Total	5967	17,606	2042	25,615

Note: Median values are underlined in each column.

The Injury Severity Score (ISS) distributions for these age categories were relatively flat with a predominance of injuries with ISS between 0 and 9, as shown in Table 3. An isolated talus fracture could have an ISS of 9 or below if it were considered to be an injury below the threshold denoted as severe. Overall, 11% of the injuries were from isolated talus fractures and 89% had an additional injury. The overall mean ISS score was 12.57.

Table 5
Associated injury incidences by age.

Associated Injuries	Age		
	18–39	40–64	65+
Head Injury	24.28	20.33	19.58
Skull Fracture	12.97	9.93	6.88
Intracranial Injury	15.64	13.91	15.07
Spinal Injury	20.25	24.59	26.96
Cervical Spine	4.36	6.38	9.13
Thoracic Spine	5.73	7.43	9.64
Lumbar Spine	12.71	15.45	15.20
Sacral Spine	4.41	3.77	3.44
Ribs/Sternum	19.52	28.80	35.41
Pelvic Fracture	12.78	11.61	10.19
Acetabulum	8.21	7.07	4.80
Pubis	4.06	3.87	3.91
Ilium	1.44	1.28	1.61
Ischium	0.31	0.30	0.51
Upper Extremity Fracture	23.84	26.75	26.96
Clavicle Fracture	3.32	3.64	3.99
Scapula Fracture	2.37	2.54	2.34
Humerus Fracture	4.07	4.18	4.33
Proximal Humerus	1.33	2.06	2.00
Humeral Shaft	1.43	1.04	1.19
Distal Humerus	1.25	1.00	1.02
Radius/Ulna Fracture	11.11	13.00	13.16
Proximal Radius/Ulna	2.40	2.66	2.17
Radial/Ulnar Shaft	3.01	2.84	2.68
Distal Radius/Ulna	6.02	8.04	8.58
Hand Fracture	9.31	10.70	10.96
Other Lower Extremity Fracture	73.02	81.32	83.91
Femur Fracture	8.42	9.91	11.17
Proximal Femur	4.13	4.79	5.73
Femoral Shaft	8.51	4.94	2.97
Distal Femur	3.73	5.14	5.48
Patella Fracture	5.25	5.43	6.28
Tibia/Fibula Fracture	52.51	61.85	68.83
Proximal Tibia/Fibula	7.62	12.20	11.38
Tibial/Fibular Shaft	10.81	13.36	12.36
Ankle Fracture	38.18	45.71	55.75
Medial Malleolus	15.66	16.50	17.88
Lateral Malleolus	9.18	12.11	13.33
Bimalleolar	5.78	8.41	14.14
Trimalleolar	2.37	4.63	8.83
Other Foot Fractures	40.54	46.40	43.10
Navicular	8.18	8.23	7.43
Cuboid	11.42	11.83	9.85
Cuneiforms	4.31	4.60	3.57
Metatarsals	14.04	16.30	15.67
Phalanges	3.09	4.52	4.03
Thoracic Organ Injury	21.07	17.57	19.92
Heart	0.59	0.82	1.15
Lung	20.53	16.81	19.07
Pneumothorax	12.88	11.51	13.76
Diaphragm	0.35	0.46	0.55
Abdominal Organ Injury	14.92	11.71	9.98
GI Tract	3.48	3.62	3.14
Liver	7.25	4.29	2.97
Spleen	6.19	4.07	3.27
Kidney	2.27	1.44	1.02
Pelvic Organ Injury	0.78	0.63	0.30

Note: All values are percentages of talus fracture patients in the column-specified age range with the associated injury.

Although most patients had an ISS between 0 and 9 regardless of mechanism, ISS was higher for MVAs, compared to other mechanisms. Mean ISS scores were 7.89, and 14.98, and 8.93 for patients with falls, MVAs, and other mechanisms, respectively. In general, this demonstrates that many patients with talus fractures present with other injuries and have injury severity scores that suggest that the injury was not isolated to the talus.

3.3. Mechanism of injury

Fig. 2 shows the mechanism of injury distribution by age. Overall, MVAs were far more common than falls or other injury mechanisms. As expected, MVAs were more common in younger patients, while falls were more common in older patients. Table 4 demonstrates that MVAs had a higher ISS compared to falls and other injury mechanisms. Of all male patients, 27.2% suffered falls, while 62.7% suffered MVAs. Of all female patients, 17.1% suffered falls, while 78.2% suffered MVAs.

3.4. Associated injuries

Overall, 89% of patients with a talus fracture had an associated injury. Ankle fractures (42.7%) and calcaneus fractures (27.8%) were the most common bony associated injuries. Ribs/sternum fractures (24.5%), lumbar spine injuries (14.0%), pelvic fractures (12.1%), and radius/ulna fractures (12.0%) were relatively common as well.

Lung (19.0%) and intracranial (14.9%) injuries were the most common internal organ injuries. Abdominal organ injuries appeared in 13.2% of patients, with dominant subcategories being liver (5.7%) and spleen (5.1%) injuries.

Table 5 summarizes the associated injury frequencies by age category. Figs. 3 and 4 show the overall incidences of select bony and internal organ associated injuries, respectively, in different body regions. Darker shadings on grayscale correspond to higher frequencies.

4. Discussion

Understanding the epidemiology and injuries associated with specific orthopaedic fractures is of known clinical importance. Calcaneus, scapula, and femoral shaft fractures have known associations with lumbar spine, thoracic, and ipsilateral femoral neck injuries, respectively.[3–5] Though talus fractures are less common, demographic, injury characteristics, and associated injuries are not as well these fractures.[7] In this context, the goals of the current paper were to explore these characteristics for talus fractures from a large national dataset.

The current study identified over 25,000 talus fractures between 2011 and 2015 in the NTDB. These were predominantly in males with peak incidence noted in the 18–38 age group. These demographics are similar to the level 1 trauma cohort study by Elgafy et al.[8] As could be expected comorbid medical conditions increased with increasing patient age.

Injury severity decreased with patient age but was greatest in those who sustained their injuries from MVA (as opposed to from falls). The lower mechanism fall injuries leading to talus fractures in the older may be associated with lower bone density.[13] The association of talus fracture with MVAs is consistent with the prior data.[8]

Overall, 89% of patients with a talus fracture had an associated injury. This high fraction suggests that associated injuries should be suspected in these patients. The injury pattern of patients with talus fractures was assessed by first analyzing specific associated skeletal injuries. The present study is the first, to our knowledge, to complete such an analysis.

Local associated injuries were common, with over 77% of

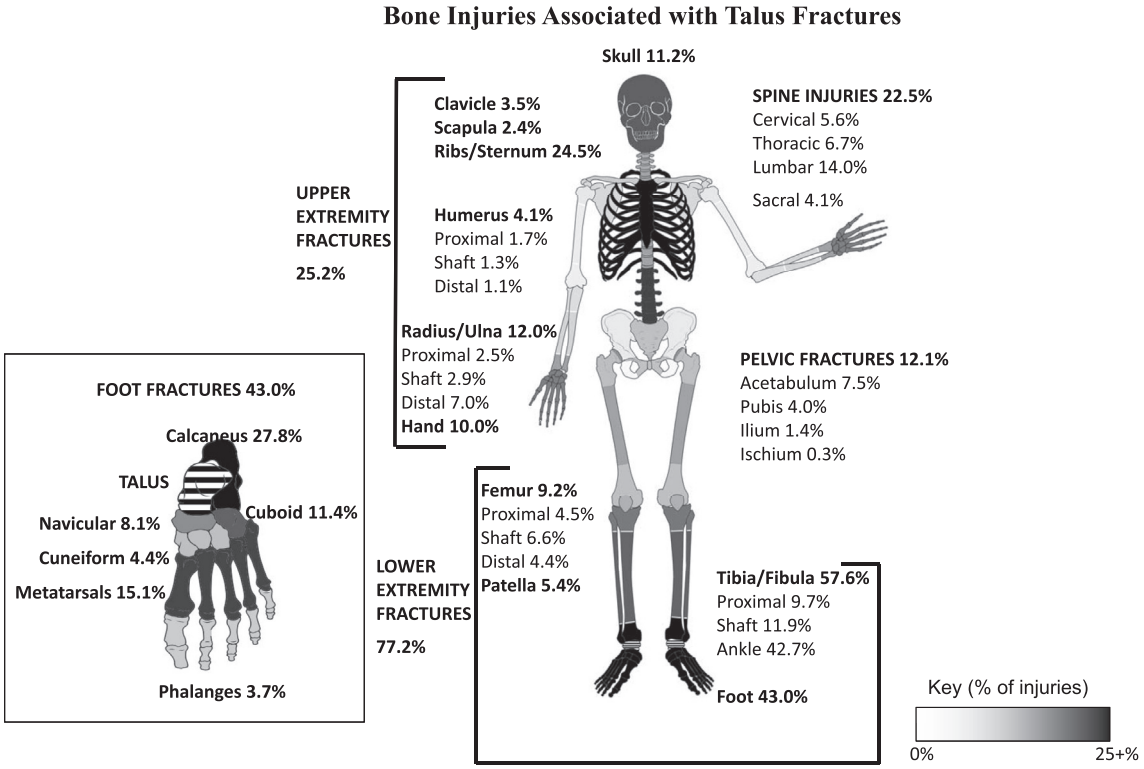

Fig. 3. Schematic representation of percentages of talus fracture patients who are over 18 years old with incidence of associated bony injuries in different body regions. Darker shadings in grayscale correspond to higher frequencies of associated injuries.

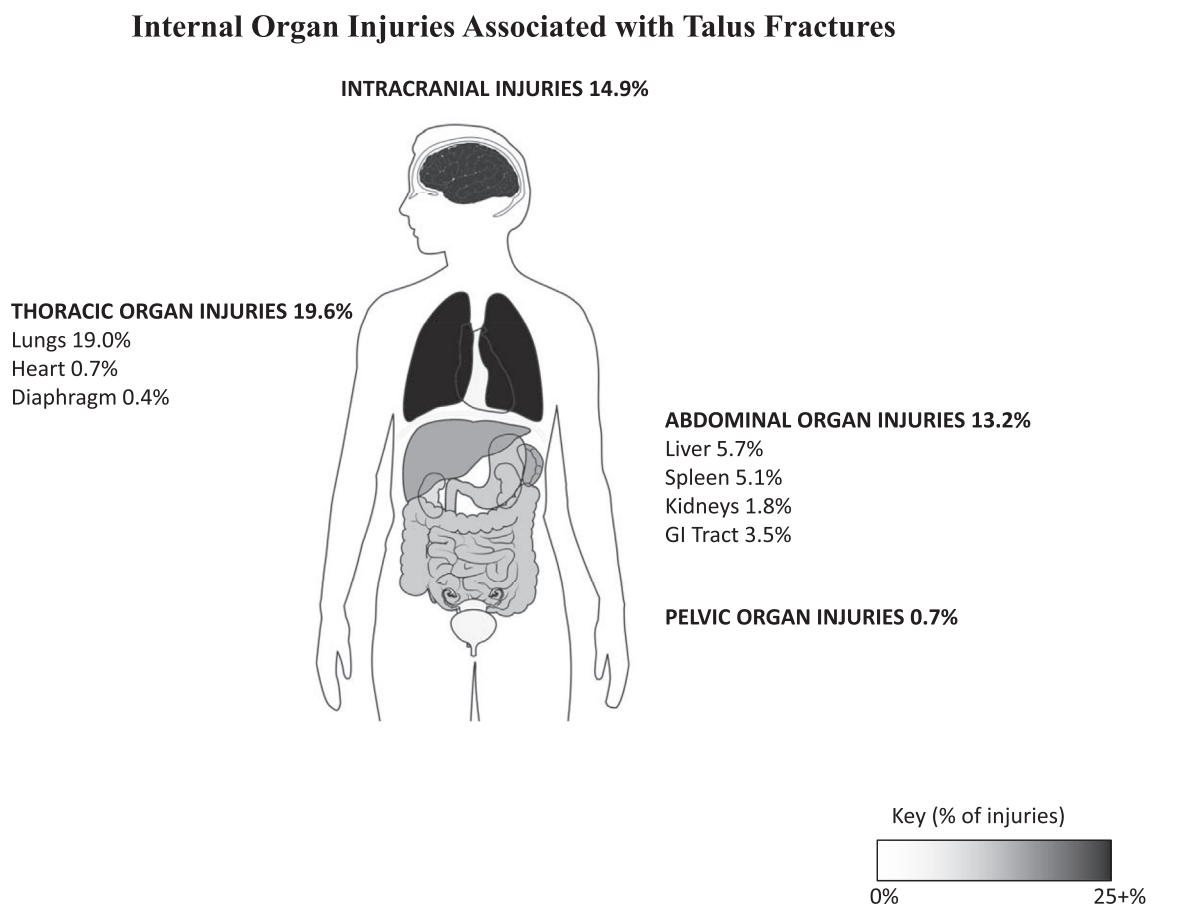

Fig. 4. Schematic representation of percentages of talus fracture patients who are over 18 years old with incidence of associated internal organ injuries in different body areas. Darker shadings in grayscale correspond to higher frequencies of associated injuries.

patients having a concurrent lower extremity fracture. Of these, the most common were adjacent injuries, especially ankle fractures (42.7%). The most common foot fracture was a calcaneus fracture occurring in 27.8% of patients with talus fracture. These high rates of local fracture confirm the need for physicians to continue to closely evaluate the bony anatomy of this region for patients sustaining a talus fracture, via physical exam and/or imaging.

There were also significant rates of distant fractures as well: for example, upper extremity fractures (25%) as well as spine injuries (23%). The spine injuries were mostly lumbar spine with 14% of all patients with talus fractures having lumbar injury. The incidence of injuries at distant sites, while echoing the results of a previous calcaneus injury study by Worsham et al., has not previously been reported with respect to talus injury.[2] Physicians treating talus fracture patients should assess the distant skeleton and also should have a low threshold for ordering upper extremity and spine imaging.

Internal organ injuries were also assessed. Nearly one in five patients had concurrent thoracic organ injury followed closely by 15% of the population sustaining intracranial injury and 13% of patients suffering abdominal injury. These percentages may guide emergency care providers to lower their threshold to examine and imaging these areas of the body, which have never been taught as areas of associated injury with talus fracture.

Overall, the current study is limited by the general limitations of database studies. Specifically, it only includes patients that were admitted to a trauma center after the initial accident, and does not include patients who died on scene or were taken to a facility that does not participate in NTDB. Further, the talus fractures could not be sub-classified. However, the large dataset that the NTDB allowed for a large scale study of a less common fracture. Lastly, another limitation is that the NTDB does not delineate whether a there were pre-existing injuries in patients or whether patients suffered injuries on multiple occasions.

5. Conclusion

In summary, the current study examined a nationwide sample of 25,615 talus fractures and reports demographics, mechanisms of injury and injury severity scores that were in line with previously published cohort studies. It also contributes the first known analysis of specific bony and internal organ associated injuries in patients with talus fractures. The results of this study suggest that there should be a low threshold for evaluation of given bony and internal injuries that have defined associations with talus fractures in the trauma patient population.

IRB approval

A waiver was issued for this study by our institution's Human Investigations Committee.

Appendix 1. International Classification of Disease, Ninth Revision (ICD-9) diagnosis codes for bony injuries associated with talus fracture

Injury	ICD-9 diagnosis codes
Skull fracture	800.00–804.99
Spinal injury (cord or vertebrae)	All subcategories listed below
Cervical spine injury	805.00–805.19, 806.00–806.19, 952.00–952.09
Thoracic spine injury	805.2, 805.3, 806.20–806.39, 952.1
Lumbar spine injury	805.4, 805.5, 806.4, 806.5, 952.2
Sacral spine injury	805.6, 805.7, 806.60–806.62, 806.69, 806.70–806.72, 806.79, 952.3, 952.4
Rib/Sternum injury	807.0, 807.00–807.19, 807.1, 807.2, 807.3, 807.4
Pelvic fracture	808.40–808.59, 808.8, 808.9 + All subcategories listed below
Acetabulum fracture	808.0, 808.1
Pubis fracture	808.2, 808.3
Ilium fracture	808.41, 808.51
Ischium fracture	808.42, 808.52
Upper extremity fracture	818.0, 818.1, 819.0, 819.1828.0, 828.1 + All subcategories listed below
Clavicle fracture	810.00–810.19
Scapula fracture	811.00–811.19
Humerus fracture	812.2, 812.3 + All subcategories listed below
Proximal humerus fracture	812.00–812.19
Midshaft humerus fracture	812.21, 812.31
Distal humerus fracture	812.40–812.59
Radius/Ulna fracture	813.80–813.83, 813.90–813.93 + All subcategories listed below
Proximal radius/ulna fracture	813.00–813.19
Midshaft radius/ulna fracture	813.20–813.39
Distal radius/ulna fracture	813.40–813.59
Hand fracture	814.00–817.19
Lower extremity fracture	819.0, 819.1, 827.0, 827.1, 828.0, 828.1 + All subcategories listed below
Femur fracture	821.00, 821.10 + All subcategories listed below
Proximal femur fracture	820.00–820.99
Midshaft femur fracture	821.01, 821.11
Distal femur fracture	821.20–821.39
Patella fracture	822.0, 822.1
Tibia/fibula fracture	823.80, 823.81, 823.82, 823.90, 823.91, 823.92 + All subcategories listed below
Proximal tibia/fibula fracture	823.00–823.19
Midshaft tibia/fibula fracture	823.20–823.39
Ankle fracture	824.0–824.9
Foot fracture	825.20, 825.26–825.29, 825.30, 825.36–825.39 + All subcategories listed below
Calcaneus fracture	825.0, 825.1
Talus fracture	825.21, 825.31
Navicular fracture	825.22, 825.32
Cuboid fracture	825.23, 825,33
Cuneiform fracture	825.24, 825.34
Metatarsal fracture	825.25, 825.35
Phalanx fracture	826.0, 826.1

Appendix 2. International Classification of Disease, Ninth Revision (ICD-9) diagnosis codes for internal organ injuries associated with talus fracture

Injury	ICD-9 diagnosis codes
Intracranial injury	850.00–854.19
Thoracic organ injury	862.10–862.99 + All subcategories listed below
Heart injury	861.00–861.19
Lung injury	861.20–861.39
Diaphragm injury	862.0, 862.1
Abdominal organ injury	868.00–868.19 + All subcategories listed below
Liver injury	864.00–864.19
Spleen injury	865.00–865.19
Kidney injury	866.00–866.19
GI tract injury	863.00–863.99
Pelvic organ injury	867.00–867.99

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