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Open Talus Fractures: Early Infection and Its Epidemiological Characteristics

Xi Liu, MD, Hui Zhang, MD, Lei Liu, MD, Yue Fang, MD, Fuguo Huang, MD

Department of Orthopaedic Surgery, West China Hospital, Chengdu, Sichuan Province, China

ABSTRACT

Open talus fractures are relatively rare and severe open injuries with a high risk of severe infection. To better understand the epidemiological characteristics of this kind of injury, a monocentric case review was conducted among open talus fracture patients admitted in West China Hospital of Sichuan University between January 2010 and December 2014. Fifty-one (N = 51) patients were recruited to the study, including 44 (86.3%) males and 7 (13.7%) females. Fifty-two cases of open talus fractures were diagnosed among the patients (1 patient had bilateral fractures). The primary cause of open talus fracture was a fall from a height. The rate of concurrent injuries associated with open talus fracture was 84.3%. The overall infection rate was 41.2%, rising with the increase of injury severity classified by Gustilo-Anderson classification and the existence of peritalar dislocation. Therefore, it can be concluded that open talus fractures are at high risk of concurrent complications and early infection. It is necessary to perform a complete physical examination to search for possible concurrent injuries. When evaluating the risk of infection, in addition to the severity of open talus fracture, the existence and severity of peritalar dislocation should also be taken into consideration.

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Open talus fractures are relatively rare but severe open injuries, accounting for 20% to 25% of all fractures of the talus (1). Infection is 1 of the most significant challenges in the early stage of its treatment. The specific anatomical location and morphology of the talus make it quite different from most of the other open fractures in regard to the clinical manifestation. Considering that talus articulates with calcaneus, the distal end of tibia, and naviculum, meaning that 60% of its surface is an articular facet, it is subject to extensive intra-articular infection, which leads to severe consequences (1). Meanwhile, unlike closed fractures, open talus fractures are usually accompanied with massive tissue damage, which could destruct the integrity of skin, subcutaneous soft tissue, joint capsule, ligaments, and even joint surface, therefore causing a significant defect. Moreover, the lack of muscular attachment to talus itself makes bone extrusion likely (2). Therefore, the risk of infection for open talus fracture is relatively high (3).

To date, studies covering various aspects of all talus fractures have been published. However, to our knowledge, investigations specifically focused on open talus fracture with a large sample size still remain lacking, and therefore there is a need to better understand the epidemiological characteristics of occurrence of early infection after open talus fractures. The aim of the current study is to provide clinical data about open talus fractures in regard to the demographic distribution, onset, and severity of infection after open talus fractures and the possible influencing factors obtained at a single level 1 trauma center.

Patients and Methods

Study Design and Patient Selection

A monocentric medical record review was conducted at a level 1 trauma center, with ethics approval given by the ethics committee of the institution. A thorough investigation of the hospital information system database from January 2010 to December 2014 was carried out. Patients with open talus fractures were selected from all patients suffering talus fractures and included in the current study with informed consent. The included patients were accrued to treatment. All operations were carried out by a senior orthopaedic surgeon (H.Z.). The patients were followed for a mean of 16.7±3.1 (range 12 to 24) months after the injury (4,5).

Patients were excluded from this study if (1) the patient died during the follow-up period for reasons other than the injury, (2) the patient underwent amputation of the injured limb within the follow-up period before infection occurred, (3) the patient lost contact during the follow-up period, or (4) the patient's medical record failed to provide sufficient information for the current study.

A table was designed to collect the needed clinical data from each patient involved. Information obtained included the patient's name, admission number, age, gender, smoking status (smoking or not), the trauma cause, the complete clinical diagnosis, the Gustilo-Anderson classification category (6,7), the time from injury to the first debridement, the time from injury to definitive treatment, whether a vacuum-assisted closure (VAC) system was used during the first debridement surgery, and whether signs of infection were observed (and if yes, whether the infection was

superficial or went deep into tissues). The radiographic data, including pre- and postoperative x-ray images of each patient, were also collected to see if there was peritalar dislocation (dislocation of the tibiotalar, subtalar, and talonavicular joints) and its extent. The data were independently assessed by 2 assessors who were blinded to the patient treatment (Y.F. and F.H.).

Diagnostic Criteria for Infection

Infection was diagnosed according to the criteria of Willenegger and Roth (5). The diagnosis was made based on the presence of signs and symptoms of infection such as pain out of the area of injury, swelling, redness, purulent drainage, and high fever with a body temperature >38.5°C, along with laboratory test results such as an increased white cell count, continuously or increasingly raised erythrocyte sedimentation rate and C-reactive protein, as well as positive fluid culture results (4,5,8,9).

Statistical Analysis

Statistical analysis was performed with SPSS 19.0 (SPSS Inc., Chicago, IL) by an independent researcher (L.L.). Quantitative data were presented as a means ± standard deviation. A p value of ≤.05 was considered statistically significant. Information was summarized in statistical charts. Comparisons were made among continuous variables using the analysis of variance test along with the Fisher's exact test or χ^2 test as appropriate among categorical variables.

Results

The investigation yielded 261 patients with talus fractures. A total of 51 (19.5%) patients with 52 feet suffered open fractures. Forty-four (86.3%) patients were male, and 7 (13.7%) were female. The mean age of the patients was 40.7 years (40.6 years in males and 41.1 years in females). Among these patients, there were 24 smokers, accounting for 47.1% of patients. The only patient with bilateral open talus fracture was a nonsmoker. The most frequent reason for the injury was falling from a height >1 m. This reason applied to 19 (37.3%) cases, followed by motor vehicle accidents with 9 (17.6%) cases. Other observed reasons for the open talus fracture included motorcycle or electromobile accidents, pedestrian versus automobile accidents, and crush or mangled injuries (Fig. 1).

Open talus fractures caused by mechanisms other than the 5 common reasons mentioned in Fig. 1 were relatively rare, including gunshot injury in 1 case, falling while playing basketball in 1 case, falling from a 50-cm height while carrying heavy items in 1 case,

and being hit by a pile driving machine in a construction area in 1 case (Fig. 1).

According to the Gustilo-Anderson classification system, the injuries included in the current study were classified into the following categories: 6 (11.8%) type II cases, 23 (45.1%) type IIIA cases, 19 (37.3%) type IIIB cases, and 3 (5.9%) type IIIC cases. No Gustilo-Anderson type I patients were included in the current study (Fig. 2).

Concurrent injuries were present in 43 (84.3%) patients. There was a wide range of concurrent injuries involving almost the entire body. The most frequent concurrent injury was malleolar fracture, followed by calcaneus fracture (Fig. 3).

As can be seen from Table 1 and Fig. 4, only 15 (29.4%) patients had no associated dislocation or subluxation of the subtalar joint, tibiotalar joint, or talonavicular joint in the current study (Table 1, Fig. 4).

All patients underwent emergent irrigation and debridement, open reduction either via the wound or newly made incisions, and external fixation. The alignment of the fractured talus was restored. VAC was performed, if necessary, based on the wound status. Definitive treatment was not carried out until swelling subsided and signs of infection were excluded (10,11). The time duration was 7.7±4.3 hours from injury to the first debridement and 13.2 ± 5.8 days from injury to definitive treatment. The VAC system was used in 23 (45.1%) patients to treat the injuries. Among these patients, the wound was closed at the primary attempt in 8 (15.7%) of 51 patients, and the remaining 20 (39.2%) patients were treated with conventional dressing exchange. Infection was present in 21(41.2%) patients and on 22 (42.3%) feet (1 patient had open talus fractures bilaterally), of whom 17 (81.0%) patients had deep infections and 4 (19.0%) patients had superficial infection. Among them, infection occurred early (within 2 weeks) after injury in 18 (85.7%) patients, and delayed infection occurred in only 3 (14.3%) patients. According to the Gustilo-Anderson classification system, there were no infected type II patients, 8 (38.1%) infected type IIIA patients, 12 (57.1%) infected type IIIB patients, and 2 (9.5%) infected type IIIC patients, and the infection rates were 0%, 34.8%, 63.2%, and 66.7%, respectively (Tables 2 and 3). The dislocation status of the associated joints in the infected patients was also analyzed (Table 2). There was 1 (6.7%) infected patient without dislocation, 4 (36.4%) had monoarticular dislocation, 11 (57.9%) had biarticular dislocation, and 5 (71.4%) had triarticular dislocation (Table 3).
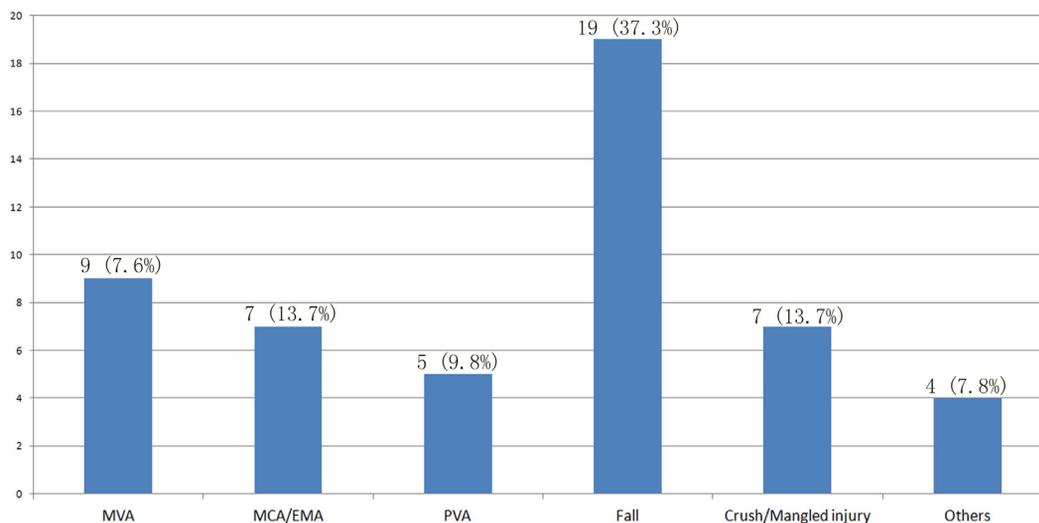

Fig. 1. Primary causes for open talus fractures and their corresponding frequency. All open talus fractures in the current study were high energy related. Falling is the most common reason for open talus fractures. Abbreviations: EMA: electromobile accident; MCA, motorcycle accident; MVA, motor vehicle accident; PVA, pedestrian versus automobile.
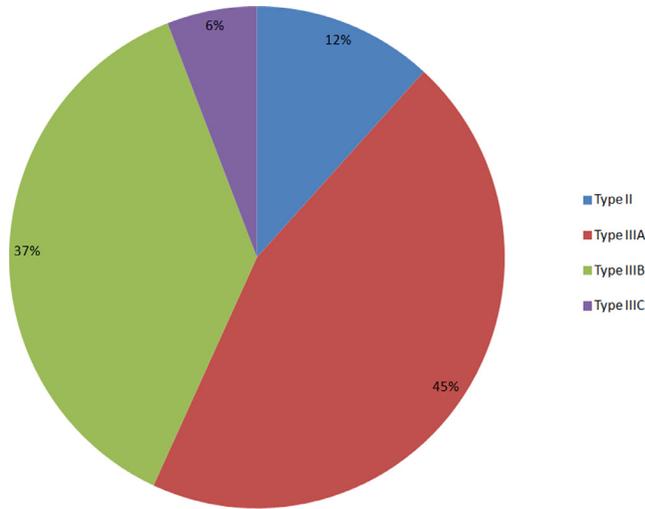
Fig. 2. Distribution of all patients in the current study according to the Gustilo-Anderson classification system. Most cases fell into types IIIA and IIIB.

Discussion

To our knowledge, this is the first study focusing on the epidemiology of open talus fractures with a relatively large sample size. Fifty-two (19.9%) patients were diagnosed with open talus fractures among all talus disorders screened in our study. The scarcity of other diseases admitted to our hospital, such as tumor, malformation, and chronic infection, and the incidence of open talus fractures among all talus fractures were close to the previously reported level of 20% to 25% mentioned in the review by Vallier (1). In our report, the overwhelming majority of victims were male (6.29:1), with even a higher proportion than that reported by Sakaki et al in their epidemiological study on talus fractures including closed fractures (4.8:1) (12).

Compared with closed talus fractures patients, the patients with open talus fractures in the current study had an older average age. The mean age in the current study was 40.7 years, about 10 years older than that was reported by Sakaki et al (12). However, if patients were divided according to their age, 53.3% of them fell into the group from 40 to 60 years old and 34.8% were between 20 and 40 years old (Fig. 5). These data indicate that open talus fractures still affect relatively young adults most often.

The overall early infection rate for open talus fractures found in the current study was 36.5% (19 of 52 injured feet), and the rate for early deep infection was 27.5% (14 of 51 patients). This was unsurprisingly higher than the overall infection rate of 21% for all talar neck fractures calculated from a collective group of 76 patients in a systematic analysis (13).

The infection rate in the current study was relatively higher than most of the previous reports on open fractures in lower limbs. For example, Almeida et al (14) reported a 28% rate of infection for open tibial fractures. Chen and Vallier (15) reported a 19.5% rate of deep infection in 257 patients sustaining open fractures of the lower extremity. Molina et al (16) reported an overall incidence of deep infection of 16.1% in 355 pilon fracture patients. These data indicate that open talus fracture has a poor early prognosis and needs more attention.

The most frequent reason for open talus fractures found in our study was a fall from a height, followed by motor vehicle accidence and crush/mangled injury. This was consistent with the result of Sakaki et al (12). The first 2 most frequent reasons for open talus fracture in the current study were owing to high-energy impact, in which the force could be transmitted through the body. It explained the high rate of incidence of concurrent injuries (84.3%). For the type and location of the concurrent injuries, most were in the ipsilateral foot and ankle region, followed by the ipsilateral tibiofibular region. The force faded with the recession from the injured site, and the incidence of fracture in other parts of the body was in decline. Associated visceral, thoracic, and head and neck injuries also existed, although not many.
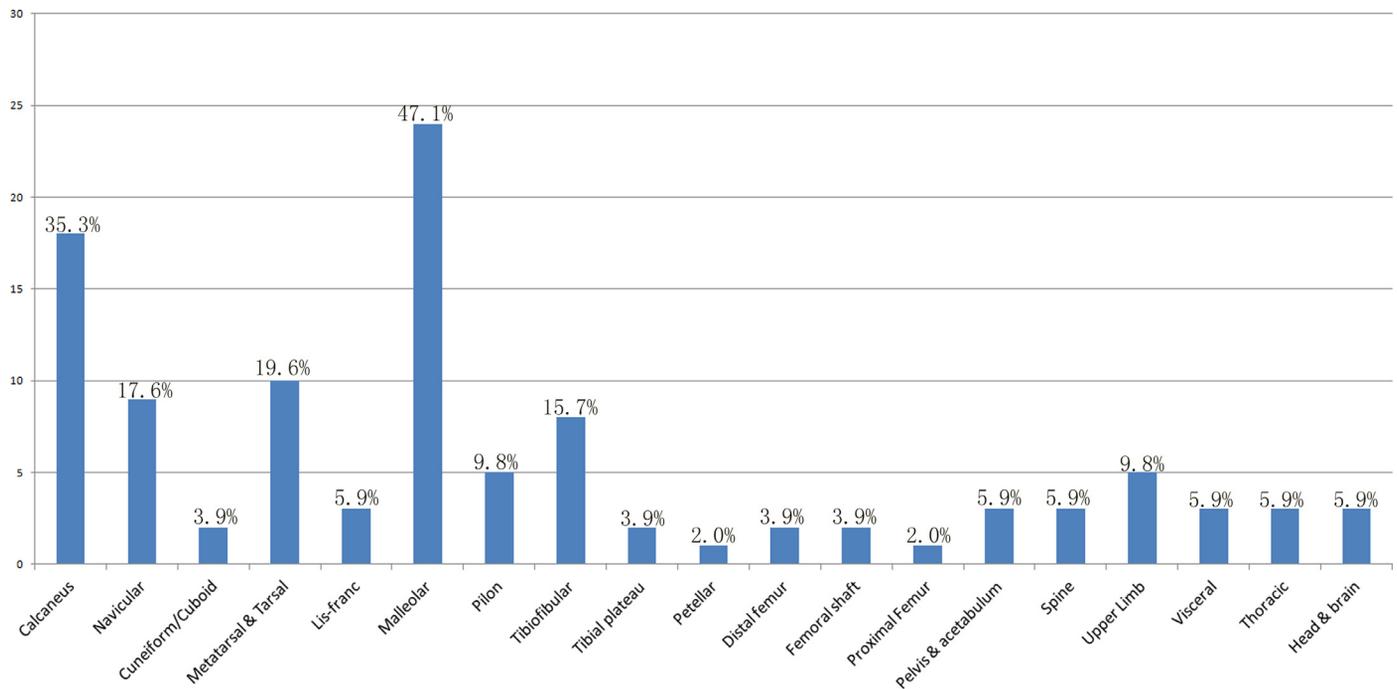

Fig. 3. Types of associated injuries and their frequency. The nearer the position was from the impaired talus, the higher was the risk of concurrent injury. Severe life-threating visceral injury coexisted with open talus fractures.
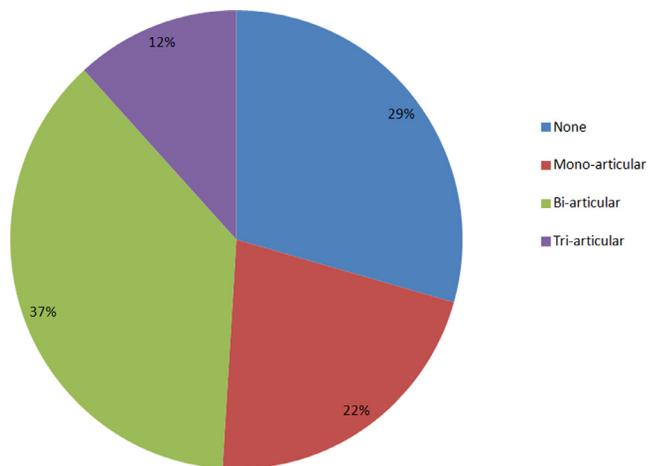
Fig. 4. Number of associated peritalar dislocations or subluxations in each patient. More than 70% of patients had associated dislocation or subluxation of the subtalar joint, tibiotalar joint, or talonavicular joint in the current study.

Table 1
Types of associated peritalar dislocations or subluxations (N= 51)

Fracture Site	No. of Cases	Dislocation	No. of Cases (%)
Neck	25	None	3 (12)
		Subtalar joint	22 (88)
		Tibiotalar joint	17 (68)
		Talonavicular joint	4 (16)
Body	13	None	2 (15.4)
		Subtalar joint	11 (84.6)
		Tibiotalar joint	7 (53.8)
		Talonavicular joint	2 (15.4)
Head	9	None	5 (55.6)
		Subtalar joint	3 (33.3)
		Tibiotalar joint	2 (22.2)
		Talonavicular joint	2 (22.2)
Processes	5	None	5 (100)
		Subtalar joint	0 (0)
		Tibiotalar joint	0 (0)
		Talonavicular joint	0 (0)

When compared with the open calcaneus fracture—another open injury of the tarsal bone, which is adjacent to the talus bone in regard to anatomical position—the result was similar. These 2 kinds of injuries shared similar causes and a similar high risk of concurrent injuries, including head, thoracic, abdominal, and pelvic and acetabular impairments (17). But differences still existed. First, based on the result of previous studies on open calcaneus fractures, it seemed that the deep infection rate was much higher for open talus fractures (28.4%) than for open calcaneus fractures (3%) (18). Second, the classification of patients according to Gustilo-Anderson classification system was dramatically different between the 2 kinds of injuries. In the study of Zhang et al (18) on open calcaneus fractures, the Gustilo-Anderson type I, II, and III patients accounted for 4.0%, 46.5%, and 49.5% of the entire group, respectively. Nevertheless, it was not further described in this study about the proportion for types IIIA, IIIB, and IIIC (17). However, in the current study, there were no Gustilo-Anderson type I patients, and

Gustilo-Anderson type II patients only accounted for 11.5% of patients. The proportion for Gustilo-Anderson type III patients was as high as 88.0%, accounting for most of the studied cases. In the Gustilo-Anderson type III subgroup, type IIIA accounted for 44% of patients and IIIB accounted for 38% of patients. The infection rate rose accordingly with the increase of Gustilo-Anderson classification grade, although the intergroup difference was not statistically significant. The insignificance might be owing to the inadequate case number in the current study, which has been proven by previous research (18).

However, there was an apparent tendency for open talus fracture patients to be concentrated in Gustilo-Anderson types IIIA and IIIB. The reason behind this result might be the fact that the talus is buried deep inside the ankle region, between the distal tibia and the calcaneus, and that it is kept in position by strong ligaments (13). It may need a stronger force to make fracture occur. But once open talus fracture does occur, the soft tissue bed is usually injured badly by furious violence, and the exposure of bone and articular surface is prompt because of the lack of muscular attachment and >60% of cartilage coverage.
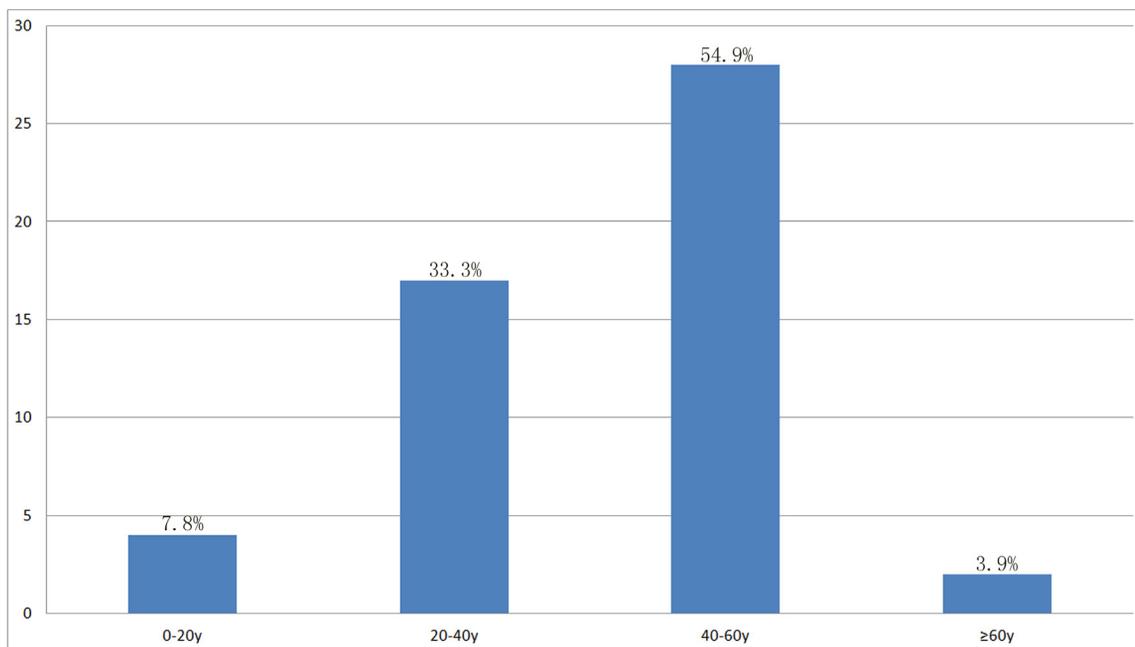

Fig. 5. Age distribution of patients in the current study. More than 90% of patients were between 20 and 60 years old.

Table 2
Infection rate and baseline balance between different groups according to Gustilo-Anderson classification (N= 51)

	Gustilo-Anderson II	Gustilo-Anderson IIIA	Gustilo-Anderson IIIB	Gustilo-Anderson IIIC	p Value
Age (mean ± SD)	46.7 ± 14.1	40.0 ± 15.3	40.0 ± 12.9	36.7 ± 20.1	.719
Gender (n1/N1, %)	83.3	91.3	75.0	100	.349
Smoking (n2/N1, %)	66.7	47.8	35.0	66.7	.524
Time (hours)	7.8 ± 2.2	6.7 ± 2.8	7.1 ± 2.6	8.3 ± 5.0	.712
Infection rate (n3/N1, %)	0	34.8	63.2	66.7	.07

Abbreviation: SD, standard deviation.
Time stands for the time period from injury to the first debridement, n1 stands for the number of male patients in each Gustilo-Anderson type subgroup, n2 stands for the number of smokers in each Gustilo-Anderson type subgroup, n3 stands for the number of infected patients in each Gustilo-Anderson type subgroup, and N1 stands for the total number of patients in each Gustilo-Anderson type subgroup.

Table 3
Infection rate and baseline balance between different groups according to the extent of peritalar dislocations (N= 51)

	None	Monoarticular	Biarticular	Triarticular	p Value
Age (mean ± SD)	44.9 ± 15.8	37.5 ± 13.1	38.1 ± 12.4	42.6 ± 17.9	.211
Gender (male) (n1/N, %)	93.3	90.9	84.2	71.4	.725
Smoking (n2/N, %)	46.7	54.5	36.8	57.1	.472
Time (hours)	7.1 ± 2.6	6.9 ± 3.2	6.9 ± 2.4	7.8 ± 3.7	.900
Infection rate (%)	6.7	36.4	57.9	71.4	.010

Abbreviation: SD = standard deviation.
Time stands for the time period from injury to the first debridement, n1 stands for the number of male patients in each Gustilo-Anderson type subgroup, n2 stands for the number of smokers in each Gustilo-Anderson type subgroup, and N1 stands for the total number of patients in each Gustilo-Anderson type subgroup.

The Gustilo-Anderson classification system has proved to be valuable in describing the severity of open fractures and estimating the risk of infection (4,19). However, in the current study, the concentration of patients in type IIIA and IIIB made this classification system less valuable for open talus fractures. Another factor that reduced its value for open talus fractures was the accompanied dislocation of the adjacent joints, which failed to be taken into consideration. It is known that osteonecrosis of the talar body is associated with the amount of initial fracture displacement (20). Although the Hawkins classification system is used only to evaluate the extent of displacement of talar neck fractures (21), the influence of peritalar dislocation on talus fractures occurring at positions other than the talar neck also seems significant (2,22,23). In addition to the impairment to the circulation of the talus, dislocation of the adjacent joints may also lead to exposure of the joint surface and extra tension to skin and soft tissue, therefore contributing to the risk of infection (24). In the current study, it is noted that the early infection rate significantly increased with the increment of existence and extent of peritalar dislocations ($p \leq .05$), which added additional evidence to support the concept mentioned earlier. Although both the grade of Gustilo-Anderson classification and the extent of adjacent joint dislocation rose with the increase of violence intensity, these 2 factors may not always positively correlate with each other in that a certain amount of closed Hawkins type III and IV talar neck fractures do exist (25,26). In addition to the strength of violence, the causes of injury might serve as an independent factor to influence the formation of open wounds (27). And a recent systematic review showed that total dislocation of the talus without fracture, whether open or closed, was associated with a high risk of infection (28,29).

We are aware that our research may have 2 limitations. First, owing to the relative scarcity of open talus fractures, there was an inadequate sample size for logistic regression analysis. The small sample size may limit our ability to discover a significant intergroup difference. Second, the retrospective nature of the current study may also bring bias. To answer the question whether the existence of peritalar dislocation and its extent is an independent risk factor for early infection after open talus fractures, a multicenter prospective cohort study or randomized controlled trial with a larger sample size is needed. We believe that the results of the current report can be useful for studies in the future.

In conclusion, the results of the current study demonstrated that open talus fractures were severe injuries with a high risk of infection and concurrent complications. These injuries threatened relatively young adults most often. When evaluating the risk of infection, in addition to the severity of open talus fracture, the existence and severity of peritalar dislocation should also be taken into consideration.

Acknowledgments

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