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Intra-articular distal tibial fractures cause a major burden to individual patients and also stresses the public health care system

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ABSTRACT

Background and purpose: Intra-articular distal tibial fractures are most commonly caused by high-energy trauma. Additional difficulties are related to accompanying soft-tissue injuries. The purpose of this study was to evaluate the consequences of different types of distal tibial fractures to the individual patient and to the public health care system.

Patients and methods: 126 patients with operatively treated intra-articular distal tibial fracture were identified between 2012 and 2016. Thirty-one (25%) were open fractures. Acute treatment, timing of definitive surgery, total number of surgical procedures, complications, need for soft-tissue reconstructions, hospital stay, and number of follow-up visits were recorded related to AO/OTA fracture types.

Results: 112 patients (89%) were treated with a staged treatment protocol. Of these patients, 74 first received an external fixation device. The definitive fracture fixation was performed on average 8 days after the trauma. Soft-tissue flap reconstruction was needed in 19 patients (15%). Additionally, 7 patients required split-thickness skin grafting. Total hospital stay ranged from 2 to 87 days (median 14 days). The median ward treatment period was 12 days in B2–3 group, 13 days in C1–2 group, and 18 days in C3 group. The median of 2 (range 1–13) surgical procedures were performed.

Interpretation: Intra-articular distal tibial fractures cause a major burden to individual patients and stresses the public health care system due to a frequent need for several surgical procedures because of soft-tissue injuries and complications. AO/OTA type C3 fractures had the greatest burden, as patients required several consecutive operations and prolonged hospital stays.

Introduction

Intra-articular distal tibial fractures (Pilon fractures) comprise less than 1% of all lower extremity fractures and 3–10% of tibial fractures [1–5]. These fractures are most commonly caused by high-energy trauma and patients often have concomitant injuries [1–3, 6]. Up to 20% are open fractures. Fibular fractures are present in 90% of cases and approximately 15% also have significant injuries in the same foot [6]. Tibial compartment syndrome is a rare but a possible additional problem in pilon fractures [7].

Due to the high-trauma energy, severe soft-tissue injuries are often involved, and these should be recognized [8]. Multiple surgical procedures are often required, sometimes with additional plastic surgical techniques [9]. In the most severe fracture types, the primary surgical procedure is commonly correction of the length and alignment with external fixation. The definitive fracture treatment is performed later, usually with locking plates [10–12]. In complicated cases, early soft-tissue reconstruction may be needed.

Our objective of this study was to evaluate the burden of intra-articular distal tibial fractures to the individual patient and to the public health care system by retrospectively collecting information of the whole treatment path in a level I trauma center from first contact up to 2 years of follow up.

Materials and methods

All patients who had surgically treated distal tibial fracture at our institution between January 2012 and December 2016 were identified by querying the hospital database. The search was performed using the International Classification of Diseases Tenth Re-

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vision (ICD-10) code for distal tibial fractures (S82.3). A total of 429 distal tibial fractures were retrieved. Our trauma hospital is the only level I trauma center in Finland and a tertiary referral center for patients with severe injuries, including distal tibial fractures. The catchment area of the hospital is 1.8 million people.

The distal tibial fractures were classified according to AO/OTA classification system [13]. A total of 126 out of 429 patients were confirmed to have an AO/OTA B2, B3, C1, C2 or C3 intra-articular distal tibial fracture (pilon fracture) at X-rays and CT scans, and form the study population. Of these, 69 (55%) were transported directly to our trauma center and the remainder had initial evaluation at other hospitals. Two patients were treated non-surgically due to poor health condition, and they were excluded from the study population.

Patient charts were reviewed in detail to collect demographic information and the number and type of surgical procedures (including soft-tissue revisions and reconstructions), delay to definitive treatment, total duration of treatment period(s) and days, total number of follow-up visits, and complications. Surgical-site infections (SSI) were classified as deep if all three of the following criteria existed simultaneously: clinical signs of infection, positive bacterial cultures from the wound or blood, and fixation material palpable or visible in the wound [14].

Cost analysis

The average hospital costs for an individual pilon fracture patient were calculated based on the costs created by the DRG-system (DRG = Diagnosis Related Group).

Statistical methods

Statistical analysis was performed using Microsoft Excel and IBM SPSS Statistics v25. ANOVA was used for comparison of means for nonparametric independent samples. Chi-square crosstab analysis was used to compare nominal samples.

Funding, and potential conflicts of interest

Funding was received from the research funds of the Department of Musculoskeletal and Plastic surgery, Helsinki University Hospital.

Declarations of interest: none.

Permission for this study was provided by the Ethical Board of Helsinki University Hospital (HUS/2188/2017).

Results

Demographics

The median age of the patients at the time of injury was 44 years (range 16–80) and male patients were overrepresented (71%). A clear majority of patients (88%) were at working age (15–64 years). 54 patients could be categorized in the lower social class according to their reported occupations.

Of 126 patients, 60 (47%) were confirmed smokers, 24 (19%) had a history of heavy alcohol abuse, 11 patients (9%) had a history of drug abuse, and 32 (25%) had a history of mental health problems.

The most common mechanism of injury was a fall from height (Table 1). Work-related injuries were observed in 20% (26 patients). Injuries occurred most often during the summer (June-August, 34%, 43 patients).

Distribution of fracture types according to AO/OTA classification and age groups is presented in Fig. 1. Five patients had bilateral pilon fractures and all had C3 pilon fracture at least on one side; therefore, these patients were included in the C3 group. Seventy-three fractures were found on the left leg and 58 on the right. Open fracture was observed in 31 patients (25%) [15]. Twenty-five (81%) were Gustilo grade IIIA, IIIB, or IIIC open injuries associated with high-energy C-type fractures (Table 2). Significant concomitant injuries occurred in 56 patients (44%).

Table 1
Injury mechanisms of intra-articular distal tibial fractures (n = 126).

Injury mechanism	B2–3 n = 32	C1–2 n = 34	C3 n = 60	Total 126
Fall from height >1 m	15 (47%)	6 (18%)	33 (55%)	54 (43%)
Same level fall	9 (28%)	14 (41%)	10 (17%)	33 (26%)
Road traffic accident	2 (6%)	5 (15%)	14 (23%)	21 (17%)
Sports-related	5 (16%)	4 (12%)	1 (2%)	10 (8%)
Car-pedestrian accident	0	2 (6%)	1 (2%)	3 (2%)
Assault	1 (3%)	2 (6%)	0	3 (2%)
Bicycle accident	0	1 (3%)	1 (2%)	2 (2%)

Table 2
Distribution of open fractures related to AO/OTA fracture types (n = 126).

	All	B2–3 type	C1–2 type	C3 type
Open fractures	31	1	5	25
Gustilo-Anderson				
I	2	1	1	–
II	3	0	3	–
IIIA	18	0	0	18
IIIB	7	0	1	6
IIIC	1	0	0	1
Closed fracture	95	31	29	35

Treatment

Definitive treatment was performed when subsidence of soft tissue swelling allowed safe operation. A total of 14/126 patients were operated within the first 3 days because of minimal swelling. Most of the patients were treated with a staged (controlled delay) treatment protocol. The definitive fracture fixation was performed on an average 8 days (median 8, range 0–20) after the injury. The pilon fracture was first stabilized with an external fixator in 74 patients (59%) and the remainder were provisionally immobilized with a plaster cast. The decision to choose external fixator or plaster cast was based on clinical findings (e.g. soft tissue injuries or other skin issues, other traumas, and stability of the fracture). Most patients (116/126) were treated with locking-plate osteosynthesis, five were treated with screw osteosynthesis, and five had spanning external fixation (with or without additional screws) as a definitive treatment. Autologous bone grafting from the iliac crest was used in 51 patients and bone-graft substitutes in 16 patients, which were used to fill the bone defect after the reduction of impacted articular fragments, when needed.

Tibial fasciotomy within 48 h of trauma was performed on nine patients (7%), of which five had an open fracture (with two Gustilo grade IIIA patients, and one grade I, IIIB, and IIIC, respectively). Five patients had delayed fasciotomy 2–13 days after injury (median 6 days), including one Gustilo grade IIIA open fracture. Tibial fasciotomy was performed when there were signs of over pressurized muscle compartments. All patients with open fracture and fasciotomy received flap coverage later (5 muscle flaps and 1 anterolateral thigh flap). Additionally, three patients required split-thickness skin graft at the time of fasciotomy closure.

Fibular fracture was observed in 96 patients (76%), of which 64 (67%) were stabilized with plate fixation.

Negative pressure wound therapy (NPWT) was received by 39 patients in the early phase of treatment because of open frac-

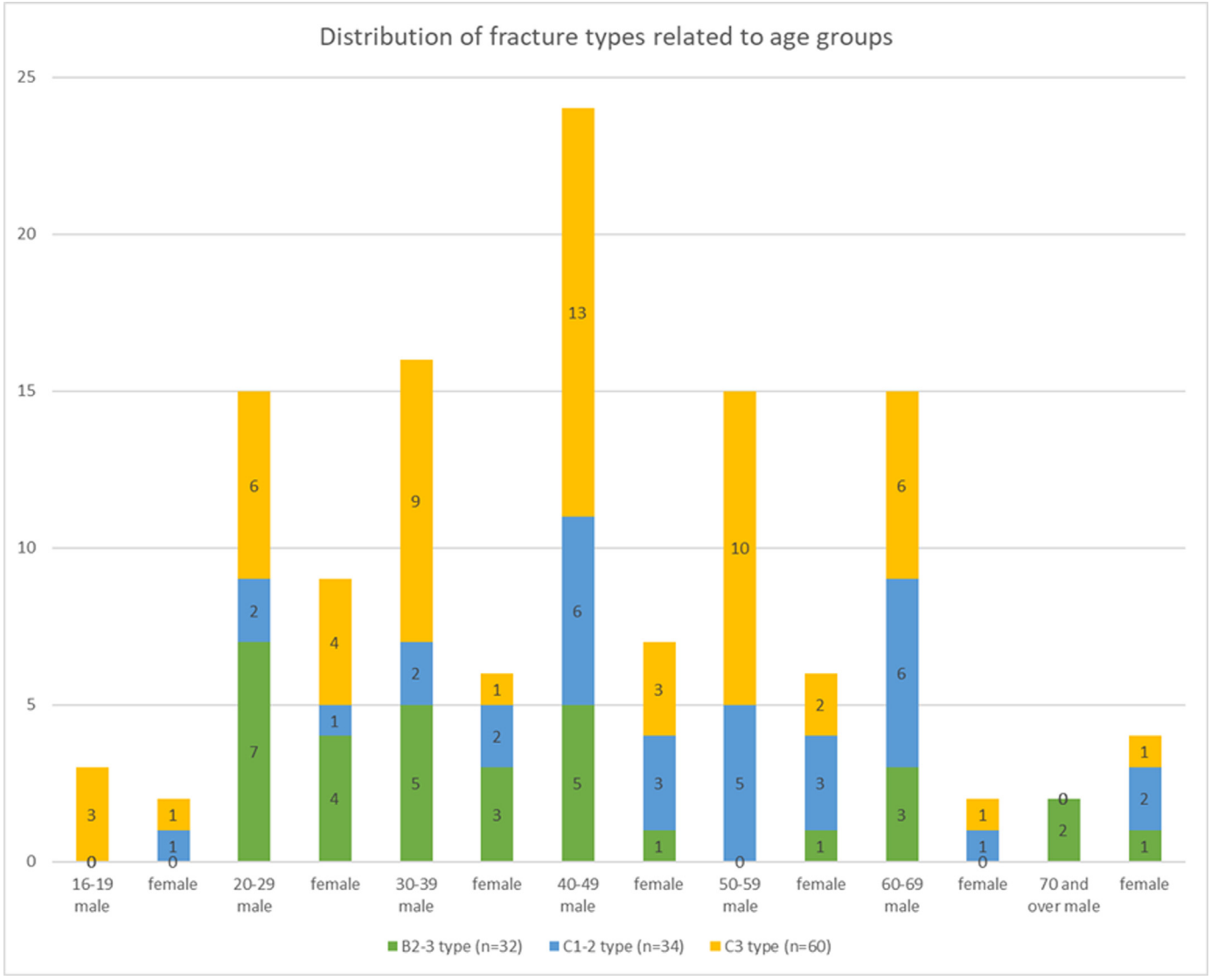

Fig. 1. Distribution of AO/OTA fracture types in different age groups (n = 126).

ture wounds and also prophylactically to manage postoperative swelling. Five patients received NPWT in later phases after complications emerged.

Soft-tissue reconstructions

Plastic surgeons performed altogether 25 flap reconstruction procedures for 19 patients (15%) to cover the defects, wounds, or both from the first hospital treatment period. These included eight dermal-subcutaneous flaps, six anterolateral thigh (ALT) flaps, and 11 muscle flaps of various origin, including distant free flaps. Additionally, seven patients required a split-thickness skin graft as the primary soft-tissue procedure. One patient with fractures in both legs also required a split-thickness skin graft to another ankle. Altogether during the first treatment period, 25 patients (20%) required soft-tissue reconstructions, and several others needed wound revisions without the need for reconstructive surgery. In the later phase, three patients (of these 19) received additional dermal-subcutaneous flap reconstruction and two muscle flaps after emergence of flap or wound problems.

Altogether 19 patients had plastic surgical outpatient clinic visits. The average number of visits was 3.5 (median 3, range 1–10). C3-type fracture patients (15 patients) required the most attention.

Follow up in the orthopedic outpatient clinic and duration of treatment periods

There was a tendency towards longer hospital stays and more frequent outpatient clinic visits with increasing injury severity (Table 3).

Complications

Fourteen patients (11%) had superficial wound infection and were treated with topical treatments and antibiotics. Deep surgical-site infection (SSI) was observed in 20 (16%) patients (14 closed fractures and 6 open fractures; 6 type C1-C2 fractures and 14 type C3 fractures) and was treated with intravenous antibiotics, surgical wound revisions, and several treatment combinations. Among patients with early plate fixation within 3 days of injury (14 patients), one had deep SSI and two had superficial SSIs. Altogether 58 additional surgical procedures were required because of infection-related issues. Six of these were muscle flap reconstructions. One patient had to undergo a vascular surgical procedure because of atherosclerosis obliterans related vascular deficiency and poor wound healing. The plate was removed at the time of the debridement in 12 patients.

Table 3
Length of hospital stay, total number of surgical procedures (including the application of external fixator when needed), and out-patient clinic visits in different intra-articular distal tibial fracture types ($n = 126$).

	All	B2-B3 type	C1-C2 type	C3 type	p-value
First ward treatment period, days median (range)	14 (2–76)	11.5 (4–37)	12.5 (2–33)	16 (3–76)	0.001
Total amount of surgical procedures, median (range)	2 (1–13)	1.5 (1–4)	1.5 (1–9)	2 (1–13)	<0.001
All ward treatment periods, days median (range)	14 (2–87)	12 (4–37)	13 (2–86)	18 (3–87)	0.002
Out-patient clinic appointments (ortho-trauma), median (range)	5 (0–28)	3 (0–28)	5 (0–22)	5.5 (0–17)	0.181
Follow-up time ended < 2 years, patients	101	29	29	43	
Follow-up continued > 2 years, patients	25	3	5	17	

Nerve injuries (most commonly strain injuries and leading to numbness) were observed in 13 patients. Four patients had thromboembolism-related complications (one each of the following: cardiac infarction, deep vein thrombosis and pulmonary embolism, muscle vein thrombosis, thromboembolism in the ALT flap).

Six patients (5%) developed severe early posttraumatic osteoarthritis and had ankle arthrodesis performed on average 17 months (median 17, range 10–22) from the injury. Five were AO/OTA type C3 fractures and one was a type B3 fracture. Three patients were primarily treated with minimally invasive screw fixation and spanning external fixator (Orthofix®) because of severely comminuted articular surface.

One patient had to undergo below-the-knee amputation 5.5 months after the injury because of poor general condition, deep wound infection, and delayed/atrophic bone healing. One patient was deceased 4 months after the injury. This patient previously had cardiac infarction, intracranial hemorrhage, and severe dementia.

95 patients had a confirmed employment/unemployment status. The rest 31 were students or pensioners or the information was missing. 14 out of 95 (15%) were unemployed at the time of injury. Because of pilon fracture 13 out of 47 patients (28%) of all employed had to change profession / work (data is missing or not reported from 48 patients).

The average cost from the first treatment period in the hospital was 13 380 euros (DRG cost), and if more complicated injuries were involved the costs could rise up to 27 280 euros. As a comparison the DGR cost for e.g. ankle fracture is 4260 euros (i.e. ankle fracture surgery and two days in the ward) in our hospital.

Discussion

During the 5-year study period, we treated on average 25 (median 30) intra-articular distal tibial fractures per year. Distal tibial fractures are relatively rare injuries and account for approximately 3% of fractures that require hospitalization among people ≥16 years in Finland. The incidence of these fractures is 15 per 100,000 individuals per year [16]. Within our material, pilon fractures comprised 29.4% of all operated distal tibial fractures. Management of pilon fracture patients is challenging. Over half of our patients had provisional external fixation prior definitive fracture treatment, and additional soft-tissue surgical procedures were required in 26% of patients. Although most of these procedures were wound revisions that an orthopedic trauma surgeon can manage, 20% of our patients required plastic surgical expertise to manage the soft tissue problems. Most of the C3-type fracture patients first required stabilization with an external fixator to correct the length and alignment. When the soft tissue swelling and the patient's general status allowed, definitive treatment was administered, which was generally a locking plate for tibial stabilization and a plate for fibular fixation, if required or if more stability was desired.

Intra-articular distal tibial fractures are often caused by high-energy trauma that frequently affects several areas of the body. In our study, significant concomitant injuries occurred in 44% of patients. The length of hospital stay increases not only due to soft-tissue injuries and wound complications but also due to polytrauma. In our material, the median ward treatment time in hospital was 14 days (range 2–87 days).

In our study, AO/OTA C3-type fractures were overrepresented in the age group of males aged 30 to 60 years (often work-related injuries), in patients with higher trauma energy (fall from height and road traffic accidents), and in open fractures. In addition, C3-type group had the most significant concomitant injuries, leading to more frequent fasciotomies, longer delay to definite treatment, more surgical procedures, bone grafting, and surgical procedures performed, longer hospital treatment periods, more surgical site infection problems and NPWTs, and more treatment days and out-patient clinic visits during the follow up. A total of 17/60 patients (28%) still had ongoing follow up at 2 years.

High trauma energy and notable comminution seem to widen the elapsed time to definitive surgery, increase the total number of surgeries performed, and increase the length of hospital ward treatment.

According to previous studies, more complex fractures are associated with lower social class, and the fracture worsens quality-of-life at 12 months of follow up after the final treatment period (distal tibial fractures, EQ5D-5 L index 0.59 vs. 0.89 in healthy population) [17]. Our results support these findings, as in our material 54% of employed and unemployed patients were categorized into a lower social class when using a classification presented previously [18]. A previous article with 3 years of follow up revealed that less than half of the patients remained unemployed; 70% of those were unemployed because of the injury. The quality-of-life of these patients as measured with SF-36 was considerably poorer than those of hip-fracture patients or even patients with AIDS [19]. A case series from an American population revealed that under a third of patients returned to their day job and over a half of the patients experienced economic distress in approximately 12 months of follow up [20].

During the years 2012–2016, the unemployment rate in Finland ranged from 6.9 to 12.0%. In this study, unemployment information was recorded from 14 patients, which is 12.6% of the potential working force (age 15–64 years, 111 of 126 patients); thus, unemployed patients are an overrepresented individual group. On the other hand, the employment rate was 73.0% in our study population, which is slightly more than that recorded in nationwide statistics (range 65.2–71.6% over the study period). Alcohol consumption may have affected the injury incidence in home-related and other injuries (19% had a history of heavy alcohol abuse). In the C1–2 type fracture patient group, the most common injury mechanism was falling at ground level or from less than 1 meter of height (41%), including more leg-twisting than crushing injuries, which suggests that there is lower-energy trauma and therefore additional injuries are rarer (26.5% in this study).

The rate of deep SSIs varies from 2% to 24% in pilon fracture patients [21–27] which is consistent with our results (16%). While there was not a single primary arthrodesis, TC arthrodesis was later performed for one type B3 fracture patient and five type C3 fracture patients (8.2% from all C3-type fracture patients) during 2 years of follow up, which appears to be consistent with the previously observed 15% in 10 years [28].

Pilon fractures are a major burden to individual patients, as even though the first operation is performed nearly at the time of arrival, the actual definitive fracture treatment is given on average after 1 week. The first ward treatment period lasts for approximately 2 to 3 weeks and an additional five visits to the outpatient clinic are subsequently required, adding up to approximately 1 year of follow up. This is in the case of a typical patient. If the trauma energy is sufficiently high, this period can be doubled. Some of these patients have severe difficulties in maintaining normal life rhythm due to alcohol abuse, psychiatric problems, drug addiction, or combinations thereof. In some cases, these problems led to the injury.

The stress to the public society is also depicted through the number of in-hospital days, surgeries, and outpatient clinic visits, and long follow up periods. Notable is also the fact that the costs of pilon fracture patient are from three to six-fold, when comparing to e.g. ankle fracture, leading to the conclusion that they present more stress to the public society.

The current study has some inherent limitations due to the retrospective design. We excluded conservatively treated patients which may lead to a minor bias in considering the whole patient group with Pilon fractures. However, we found only two patients (1.5%) whose planned operation was canceled because of patients' poor overall condition. There may also be some underreporting, particularly with patient-specific factors, such as alcohol consumption or employment status but also the length of sick leave because they are prescribed later from the primary health care level. The overall cost analysis is challenging because these patients might suffer from other injuries (e.g. spinal column, thorax, pelvis, and head). The strengths of this study include the relatively large study population including 126 consecutive patients with a minimum 2 years of patient chart follow up, an unchanged treatment protocol during the study period, and the inclusion of all different types of intra-articular distal tibial fractures.

Conclusion

We conclude that successful treatment of pilon fractures remains one of the most challenging clinical problems associated with management of high-energy trauma patients. We suggest that all C-type open and closed intra-articular distal tibial fractures should be centralized to larger trauma centers due to their rarity, need for subspecialists, and their frequent requirement for plastic surgical expertise.

Declaration of Competing Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2022.05.049.

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