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Original article

Poor prognosis for infectious complications of surgery for ankle and hindfoot fracture and dislocation. A 34-case series

Stéphanie Krissian*, Ramy Samargandi, Jérôme Druon, Philippe Rosset, Louis Romé Le Nail

Services d'orthopédie et traumatologie 1 et 2, faculté de médecine, université de Tours, CHU de Trousseau, avenue de la République, 37170 Chambray-les-Tours, France

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ABSTRACT

Introduction: Ankle and hindfoot fractures are associated with high rates of complications, and of infection in particular, for which rates of 1% to 48% are reported.
Hypothesis: Treatment of bone and joint infection (BJI) secondary to surgery for ankle or hindfoot fracture is at high risk of failure. We analyzed results of treatment of BJI in this context.
Material and methods: 33 patients (34 cases) were treated for ankle or hindfoot BJI between 2010 and 2015. Cure was defined by absence of fistula and of local or general inflammatory signs and by normal C-reactive protein level, at a minimum 2 years' follow-up. Fusion without infection was counted as success; recurrent infection and amputation were counted as failure. Mean age at trauma was 52 years (range, 16–85 years). Median time to diagnosis of BJI was 44 days (range, 2–830 days).
Results: Mean follow-up was 20 months (range, 3–59 months). Twenty-two patients were cured (65%). Seven cases required joint fusion (21%). The failure rate was 15%, including 5 transtibial amputations. Skin cover flap was required for 15 patients (44%), at a median 33 days (range, 0–167 days).
Discussion: Despite its retrospective design and small numbers, the present study confirmed the poor prognosis of BJI following surgery for ankle and/or hindfoot fracture. Patients need to be informed of this.
Type of study and level of evidence: IV, retrospective observational.

1. Introduction

Adult ankle and hindfoot fracture accounts for 12% of all fractures [1]. Ankle fracture predominates (56%), with 13% bimalleolar, 10% tibial pilon, 9% calcaneus and 7% talus involvement [2]. A total of 64% of cases involve low-energy trauma [3]. Open fracture rates range between 3% and 18% [2,3].

Most ankle and hindfoot fractures are treated by open internal fixation [3,4]. This is associated with high rates of complications: infection, skin necrosis and scar non-healing, paralysis, osteonecrosis, non-union, malunion and osteoarthritis [5]. Infection rates range between 1% and 48% [6–12]. This wide range corresponds to differences in trauma mechanism and kinetics, initial lesions (bone, ligamentous, vascular, cutaneous, etc.), patient characteristics, treatment and follow-up. All of this may account for the relative paucity of reports of treatment outcome [13–15].

The main hypothesis of the present study was that treatment of infection following surgery for ankle and hindfoot trauma is at high risk of failure. We analyzed results and factors for failure.

2. Material and methods

2.1. Patients, inclusion/exclusion criteria

A single-center retrospective study of patient files included adult patients treated between January 2010 and December 2015 for bone and joint infection (BJI) following surgery for fracture, with or without dislocation, of the tibial pilon, malleoli, talus or calcaneus. Cases of BJI following non-operative treatment were excluded.

2.2. Population

Over the study period, 956 files featuring the code for an ankle and/or hindfoot fracture and/or for ankle and/or hindfoot BJI

Abbreviations: BJI, bone and joint infection; MDC, multidisciplinary clinic; CRIOGO, Western France BJI reference center; CRP, C-reactive protein; BMI, body-mass index; ASA, American Society of Anesthesiologists.

* Corresponding author.
E-mail address: krissianstephanie@gmail.com (S. Krissian).

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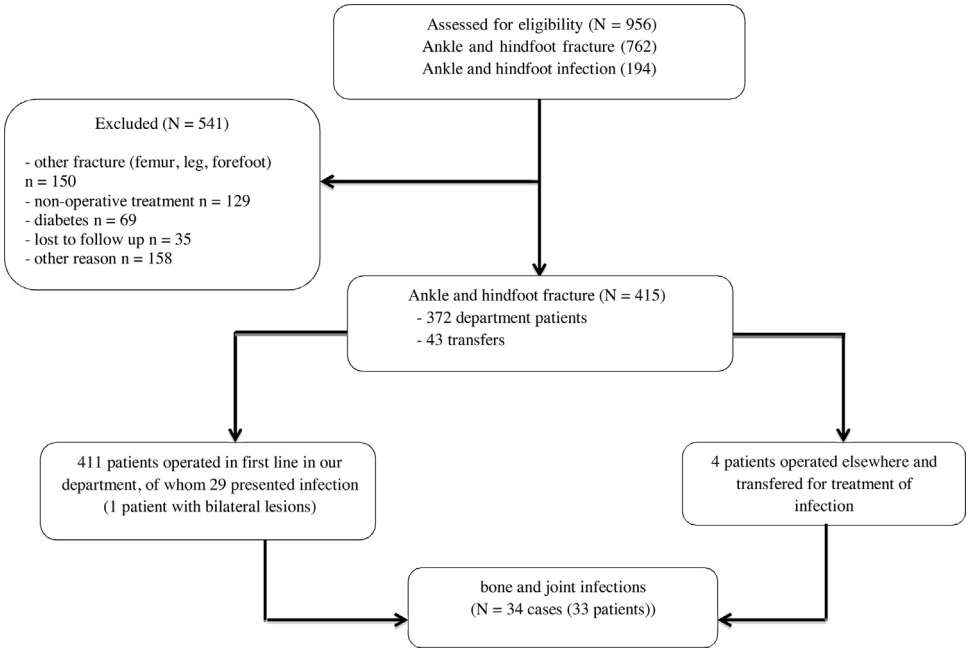

Fig. 1. Flowchart.

were reviewed; 33 patients (34 cases) were thus included (Fig. 1). Twenty-nine of these patients (30 cases) had been managed initially in the Western France complex BJI reference center (CRIOGO), and 4 had been transferred there (Fig. 1).

Table 1 shows patient characteristics. Mean age at trauma was 52 years. The main features of history were active smoking (21%), diabetes (24%), obesity, with body-mass index (BMI) > 30 (18%), and high blood pressure (39%). American Society of Anesthesiolologists (ASA) scores were 1 or 2 in 73% of cases.

A skin cover flap was required in 12% of fracture treatments and 32% of BJI treatments (Table 1). There was a single case of failure (1/4, 25%) for emergency primary flap, versus 6 for secondary flap (6/11, 55%). Median time to skin coverage was 33 days (range, 0–167 days). Free gracilis flaps were the most frequently used (9/15) (Table 1).

2.3. Study method

BJI was diagnosed for scar non-healing, purulent effusion, biological signs (leukocytes, C-reactive protein [CRP] elevation) and results for intra-operative bacteriological samples [16], in case of infection onset within 12 months of surgery [17]. Files were discussed in CRIOGO multidisciplinary clinics (MDC). Cure was defined by absence of fistula and of local or general inflammatory signs, normalization of CRP level and radiologic consolidation at a minimum 2 years. Joint fusion without recurrence of infection was counted as success. Failure was defined by recurrence of infection (onset of clinical and biological signs and positive isolate), non-union or amputation.

2.4. Surgical technique

BJI management adhered to our institution's protocol (Fig. 2). On diagnosis, revision surgery comprised wound care, bacteriological sampling and lavage. Fixation hardware was removed if bone healing allowed (i.e. > 45 days' postoperative interval). Flaps were required in 11 cases. In 3 cases, BJI was diagnosed on systematic sampling ahead of flap. Probabilistic intravenous antibiotic therapy with piperacillin/tazobactam and vancomycin was initiated after sampling and adapted according to findings after MDC discussion.

2.5. Statistical analysis

Statistical analysis used GraphPad PRISM® software. The Mann-Whitney test was used to compare non-matched non-parametric variables and the Fisher test was used for contingency tables. The significance threshold was set at $p < 0.05$.

3. Results

Mean follow-up was 20 months (range, 3–59 months). Two patients were lost to follow-up (6%).

BJI was diagnosed at a median 44 days (range, 2–830 days). Table 2 shows bacteriological findings; culture was polymicrobial in 14 cases (42%).

3.1. Failure

The rate of failure (5 amputations) without infection at a minimum 2 years was 14.7% (5/34 cases): 2 bimalleolar fractures, 1 associated tibial pilon and talus fracture, and 1 associated bimalleolar and talus fracture (Table 1). The mean number of procedures was 4.5. Two patients required flap cover.

3.2. Success

Seven cases (20%) required fusion to manage infection: 4 tibiotalar and 2 tibiotalocalcaneal fusions, in 3 bimalleolar fractures, 3 tibial pilon fractures and 1 associated talus-calcaneus fracture (Table 1). Mean number of procedures was 4. Five patients required flap cover. Radiologic consolidation was achieved in all cases, with no non-union.

As well as these 7 fusions, 22 other cases were successful. These concerned bimalleolar (14/22, 64%), tibial pilon (3/22), calcaneus (2/22), and talus fracture (1/22), pure tibiotalar dislocation (1/22) and associated bimalleolar-calcaneus fracture (1/22) (Table 1).

Table 1
Patient characteristics, BJI treatment and results.

Patient	Gender	Age[a]	Fracture site	Trauma kinetics	Skin opening	Initial treatment	Flap	Time to BJI diagnosis[b]	Infection treatment	Results (time[b])
1	M	85	Bimall	Low energy	Closed	Clou transplantaire		46	MR, P/L	Cure
2	M	30	Bimall	Unknown	Closed	P/C		174	MR, P/L	Cure
3	F	56	Bimall	Low energy	Closed	P/C		19	HR, S/L	TTC fusion (349)
4	F	69	Bimall	Low energy	Closed	P/C		92	HR, S/L	Cure
5	M	49	Bimall	Low energy	Closed	P/C		15	S/L	Cure
6	F	63	Bimall	Low energy	Closed	Plantar nail		73	HR, S/L	Cure
7	M	63	Bimall	High energy	Closed	Lateral plate		57	HR, S/L	Cure
8	F	54	Bimall	Low energy	Closed	P/C		524	S/L	Cure
9	M	53	Bimall	Unknown	Closed	P/C		543	HR, S/L	Cure
10	M	60	Bimall	Low energy	Closed	P/C		222	HR, S/L	Cure
11	F	64	Bimall	Low energy	Closed	P/C		230	HR, S/L	Cure
12	F	63	Bimall	Low energy	Closed	P/C		14	HR, S/L, EF	Amputation (941)
13	F	45	Bimall	Low energy	Closed	P/C		439	HR, F	TT fusion (486)
14	F	61	Pilon	Low energy	Closed	P/C	Gracilis	41	HR, S/L, EF	TT fusion (807)
15	M	58	Pilon	Low energy	Closed	EF	LFH	29	S/L	TT fusion (157)
16	M	32	Pilon	High energy	Closed	Plate	Split soleus	110	HR, S/L, EF	TTC fusion (113)
17	M	27	Calca	High energy	Closed	Plate	Gracilis	87	HR, S/L	Cure
18	M	26	Calca	High energy	Closed	Plate	Gracilis	33	S/L	Cure
19	M	20	Calca + bimall	High energy	Closed	EF		12	HR, S/L	Cure
20	F	49	Pilon + talus	High energy	Closed	Bilateral EF	Fasciocutaneous	830	S/L	Amputation (135)
			Pilon + talus		Gustilo II			13	HR, S/L	Amputation (1268)
21	M	45	Bimall	High energy	Gustilo II	Medial cerclage	Gracilis[c]	2	Sampling	Cure
22	M	79	Bimall	Low energy	Gustilo IIIA	Plantar nail		11	S/L	Amputation (13)
23	F	61	Bimall	Unknown	Gustilo IIIA	EF		33	HR, S/L	Cure
24	F	82	Bimall	Low energy	Gustilo IIIA	Plantar nail		199	HR, S/L	Cure
25	M	16	Bimall	High energy	Gustilo IIIB	EF	Gracilis[c]	26	S/L	Cure
26	F	62	Bimall	Low energy	Gustilo IIIB	P/C	Sural	104	Sampling	TT fusion (104)
27	M	57	Pilon	High energy	Gustilo I	EF	Gracilis	28	S/L	Cure
28	M	66	Pilon	High energy	Gustilo II	EF	Soleus	38	S/L, EF	Cure
29	F	73	Pilon	Low energy	Gustilo IIIA	EF		19	S/L	Cure
30	M	24	Talus	High energy	Gustilo II	Pins	Gracilis	9	S/L	Cure
31	M	26	Talus + bimall	Unknown	Gustilo II	EF	Latissimus dorsi[c]	637	HR, Am	Amputation (664)
32	M	57	Calca + talus	High energy	Gustilo II	Plate + screws	Gracilis	122	HR, S/L, EF	TTC fusion (122)
33	M	52	Luxation TT	High energy	Gustilo IIIB	EF	Gracilis[c]	10	Sampling	Cure

F: female; M: male; Bimall: bimalleolar; Calca: calcaneus; TT: tibiotalar; P/C: lateral plate and medial cerclage; EF: external fixator; HR: internal fixation hardware removal; S/L: sampling + lavage; F: fusion; Am: amputation/sampling: systematic ahead of flap; TTC: tibiotalocalcaneal.

[a] Years

[b] Post-fracture (days)

[c] Flap at initial fracture treatment.

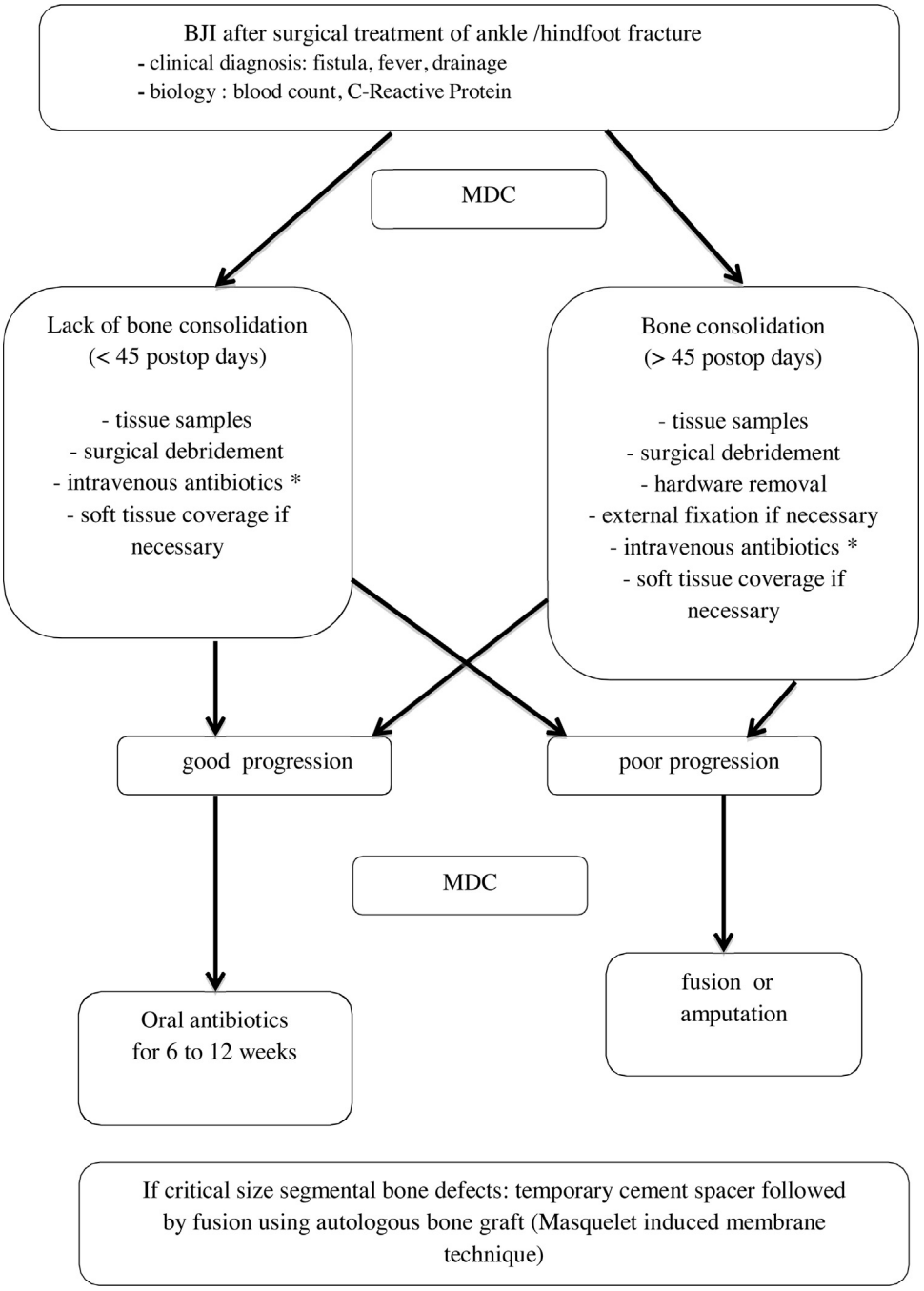

Fig. 2. BJI management protocol after surgical treatment of ankle and hindfoot fracture. MDC: multidisciplinary clinic. *: antibiotic therapy by piperacillin/tazobactam and vancomycin.

Mean number of procedures was 2.4. Eight patients (36%) required flap cover, including 2 with revision.

3.3. Statistics

There were no significant differences between the success and failure groups according to open versus closed fracture (Table 3). Skin opening grades and history were likewise comparable. Fixation hardware was removed during first BJI treatment in 60% of successful and 40% of failed cases ($p = 0.62$). The 5 cases of multiple fracture included 2 failures, compared to 2 failures in the 29 cases of single fracture ($p = 0.015$). Twenty-nine of the 34 cases of BJI had been managed initially in our center, with 31% failure of BJI treatment, compared to 60% failure in case of initial treatment elsewhere.

4. Discussion

The present study confirmed that infection following ankle and/or hindfoot fracture surgery shows poor prognosis. Despite multidisciplinary management in a reference center, there was a 15% failure rate involving amputation. The rate of fusion (consolidated without infection) was 20%. Although fusion entails stiffness and risk of decompensatory osteoarthritis in adjacent joints, we counted it as success: success was defined by resolution of

Table 2
Culprit bacteria.

Isolate	Number of patients[a]
Staphylococcus aureus	18
Enterobacter cloacae	10
Enterococcus faecalis	4
Pseudomonas aeruginosa	4
Staphylococcus epidermidis	2
other	13

[a] Number of isolates is greater than 34 due to 14 polymicrobial infections.

Table 3
Comparison of groups.

		Success ($n=29$)	Failure ($n=5$)	p	
Mean age (years)		52	53	0.98	
Gender	F	11 (38%)	3 (60%)	0.63	
	M	18 (62%)	2 (40%)		
Kinetics	High	12 (41%)	2 (40%)	1	
	Low	14 (48%)	2 (40%)		
Fracture	Open	11 (39%)	3 (60%)	0.63	
	Closed	18 (61%)	2 (40%)		
Location	Bimalleolar	17 (59%)	2 (40%)	**0.015**	
	Pilon tibial	6 (21%)			
	TT dislocation	1 (3%)			
	Talus	1 (3%)			
	Calcaneus	2 (7%)			
	Multiple	2 (7%)	3 (60%)		

n: number; F: female; M: male; TT: tibiotalar.

infection, regardless of joint motion, which is liable to be impaired after any joint fracture complicated by infection.

Risk factors for complications following calcaneal surgery in the literature comprise: ASA score > 1, absence of drainage [8], patient non-compliance [9] and the surgeon's experience [18]. Other risk factors following ankle fracture surgery comprise: diabetes, peripheral neuropathy, open fracture and patient non-compliance [19]. Numbers in the present series were too small to be able to identify particular risk factors.

There were 5 cases of transtibial amputation (15%), all following tibial pilon or bimalleolar fracture, including 3 open fractures. In the literature, amputation rates following BJI range from 0 to 50%. In the present series, 7 patients (21%) required tibiotalar or tibiotalocalcaneal fusion to manage the BJI. Heier [10] reported 11 subtalar or triple fusion procedures in 33 open calcaneal fractures (33%). Kienast [20], in a series of 133 patients with post-traumatic ankle infection with severe osteocartilaginous lesions, reported 129 tibiotalar fusions.

Zalavras [15] and Malizos [14] reported treatment protocols for BJI secondary to ankle fracture surgery. Our own protocol (Fig. 2) is based on two principles: good quality skin cover, using flaps as necessary; and removing internal fixation hardware whenever stability allows, with external fixator relay if necessary, without local antibiotic therapy, unlike Malizos and Zalavras, who prefer not to remove hardware for infection with onset within 10 weeks. In case of bone defect, fusion by Masquelet's induced membrane technique may be used. Antibiotic therapy modalities and duration depend on the isolate, presence of hardware, and diathesis.

Flap cover rates range between 15% and 40% in the literature [7,10,14,15,21,22], but timing and indications were not discussed. Like Aldridge [7], we consider skin coverage to be an integral part of the initial treatment: BJI treatment failure rates were 25% in case of initial flap cover versus 55% when flap coverage was at time of BJI treatment. This argues for multidisciplinary management from the outset, with flap coverage in case of the slightest doubt about coverage quality. We do not have experience of negative pressure therapy in these indications.

Study limitations comprise the retrospective design and small sample size. We realize that the cohort was heterogeneous, including both ankle and hindfoot fractures, but it seemed important to take account of all such fractures, notably due to the existence of multiple fracture sometimes involving both tibial pilon and talus. Management principles within our center were homogeneous, reflecting the MDC approach.

5. Conclusion

Rates of functional failure in BJI following ankle and/or hindfoot fracture were high, despite multidisciplinary team management associating orthopedic surgeons, infectologists, plastic surgeons and microbiologists. Patient information on the risk of complications is primordial, starting from the initial emergency treatment, as such complications can be serious.

Disclosure of interest

The authors declare that they have no competing interest.

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Authors' contributions

S. Krissian: Literature search, data collection, article writing and re-editing.
R. Samargandi: Literature search, data collection.
J. Druon: Re-editing.
P. Rosset: Study supervision, re-editing.
L.R. Le Nail: Co-supervisor, re-editing.
All authors read and approved the final submitted version.

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