Foot and Ankle Surgery 25 (2019) 798–803

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

Improved functional outcome after early reduction in Bosworth fracture-dislocation

Yougun Won[a,b], Gi-Soo Lee[a,*], Jung-Mo Hwang[a], Il-young Park[a], Jae-Hwang Song[a,b], Chan Kang[a], Deuk-Soo Hwang[a]

[a] Department of Orthopaedic Surgery, Chungnam National University School of Medicine, Korea
[b] Department of Orthopedic Surgery, Konyang University College of Medicine, Korea

ARTICLE INFO

Article history:
Received 23 July 2018
Received in revised form 4 October 2018
Accepted 16 October 2018

Keywords:
Bosworth
Ankle
Posterior malleolus
Fracture
Missed
Outcome
Complication

ABSTRACT

Background: Bosworth described an unusual fracture-dislocation of the ankle with fixed posterior fracture-dislocation of the fibula. Previous epidemiological data on the prevalence and characteristics of patients with Bosworth ankle fractures have been limited. Bosworth fracture-dislocations are often missed in patients with ankle fractures. We investigated the outcomes of missed diagnosis and the prevalence of Bosworth fracture-dislocation in patients with ankle fractures.
Methods: We conducted a retrospective analysis of inpatients aged 15 years and older with an ankle fracture, who underwent surgery between 2007 and 2016 in 4 Korean hospitals. The patient demographics, risk factors, fracture characteristics, treatment data, outcomes, and complications were analyzed.
Results: We reviewed 3405 hospital admissions for ankle fractures. During the study period, Bosworth fracture-dislocations were diagnosed in 51 cases. The prevalence of Bosworth fracture-dislocations (n = 51) was 1.62% among patients with ankle fractures who were enrolled in this study (n = 3140). Emergency surgery was performed within 24 h of injury in 36 cases (group A) and delayed surgery was performed in 15 cases (group B). The mean patient age at admission was 35.97 (standard deviation [SD], 1.643) years in group A and 34.33 (SD, 2.296) years in group B. Men were more commonly affected than women, with a 32:19 ratio. Most of the patients with Bosworth fracture-dislocations were young adults with high-energy trauma. The most frequent mechanism of trauma was falling down stairs (n = 27, 52.94%), followed by traffic accidents. Patient outcomes were significantly better in group A than in group B.
Conclusion: The prevalence of Bosworth fracture-dislocations was higher than expected. If unrecognized, it can result in inappropriate treatment and permanent disability. With accurate diagnosis and prompt treatment, excellent results can usually be obtained.
Level of clinical significance: 4.

1. Introduction

Bosworth fracture is characterized as a pattern of fracture-dislocation of the ankle joint in which the proximal part of the fibula is entrapped behind the posterior malleolus. Bosworth [1] first described this fracture in 1947 in a series of 5 patients and alerted readers to the poor outcome if the injury is unrecognized. Bosworth fracture-dislocations have been reported to require urgent surgery because of the associated difficulty encountered during closed reduction [2]; however, the injury is often not recognized early, delaying surgical treatment and reduction [3]. Although this type of dislocation is rare, a few studies have reported on its prevalence and outcomes.

We considered that it would be helpful to investigate the actual prevalence of this rare injury and the difference of outcomes between cases with and without early diagnosis and treatment. The purpose of this study was to compare the outcomes of patients who received early diagnosis and treatment and those who did not, and to determine the prevalence of Bosworth fracture-dislocations as part of a multicenter review of 51 cases.

2. Materials and methods

We retrospectively reviewed the medical records and radiographic images of 3405 patients with ankle fracture (age ≥ 15 years,

* Corresponding author at: Department of Orthopedic Surgery, Chung-Nam National University Hospital, 640 Daesa-dong, Jung-gu, Daejon 35015, Korea.
E-mail address: gs1899@hanmail.net (G.-S. Lee).

https://doi.org/10.1016/j.fas.2018.10.007
1268-7731/

skeletally mature) who underwent surgery between January 2007 and December 2016 at 4 university hospitals. All patients were found to have Bosworth fracture-dislocation based on preoperative plain radiographs including oblique-view or computed tomography (CT) images; patients without these images were excluded. Moreover, all cases of open ankle fractures were excluded from this study. However, there was no case of Bosworth fracture-dislocation among the open ankle fracture cases in this review. All procedures were performed or supervised by an orthopedic surgeon with orthopedic trauma fellowship training. The minimum follow-up duration of all patients was 12 months or until established treatment failure (Figs. 1 and 2).

We assessed the data of patients with Bosworth fracture-dislocations, including age, sex, mechanism of injury, time from the injury to surgery, surgical method (staged operation), length of stay, and occurrence of complications. Surgery within 24 h of injury was defined as urgent surgery (group A). Patients who underwent surgery after 24 h from injury were defined as having delayed treatment and classified as group B. Patients were followed up at approximately 6-week, 3-month, 6-month, and 12-month intervals. The American Orthopedic Foot and Ankle Society (AOFAS) score was determined at the 12-month visit.

All statistical analyses were conducted with SPSS software version 24.0 for Windows (SPSS Inc., Chicago, IL, USA) or SAS software version 9.4 (SAS Institute, Cary, NC, USA). The Mann–Whitney U-test and Fisher's exact test were used to compare the 2 groups.

The study has been reviewed and approved by our institutional review board (CNUH 2018-03-069).

3. Results

Of the 3405 cases, 485 were assessed and confirmed to have the axilla sign in mortise view or the fibular position in external oblique radiographs by 1 author (GS Lee). The remaining cases (n = 2751) were assessed using CT. A total of 169 cases were excluded because of the absence of the above-mentioned features, and 96 cases were excluded for being open fractures. Finally, 3140 patients with ankle fractures were included in this study. The prevalence of Bosworth fracture-dislocations (n = 51) was 1.62%.

Fifty-one (1.62%) patients were diagnosed as having Bosworth fracture-dislocation (mean age, 35.49 years), including 32 men (mean age, 35.38 years) and 19 women (mean age, 35.68 years). Emergency surgery was performed within 24 h of injury in 36 cases (group A), and delayed surgery was performed in 15 cases (group B). In group A, 29 of 36 patients were preoperatively diagnosed as having Bosworth fracture-dislocations. The remaining 7 patients in group A were not recognized to have Bosworth fracture-dislocation

Fig. 1. Bosworth fracture-dislocation image. (a) The axilla sign is visible on mortise view. (arrow) (b) Posterior subluxation of the talus on lateral radiograph. (c) The fibula is positioned in the middle of the talar body on external oblique radiograph. (d) Axial computed tomography image.

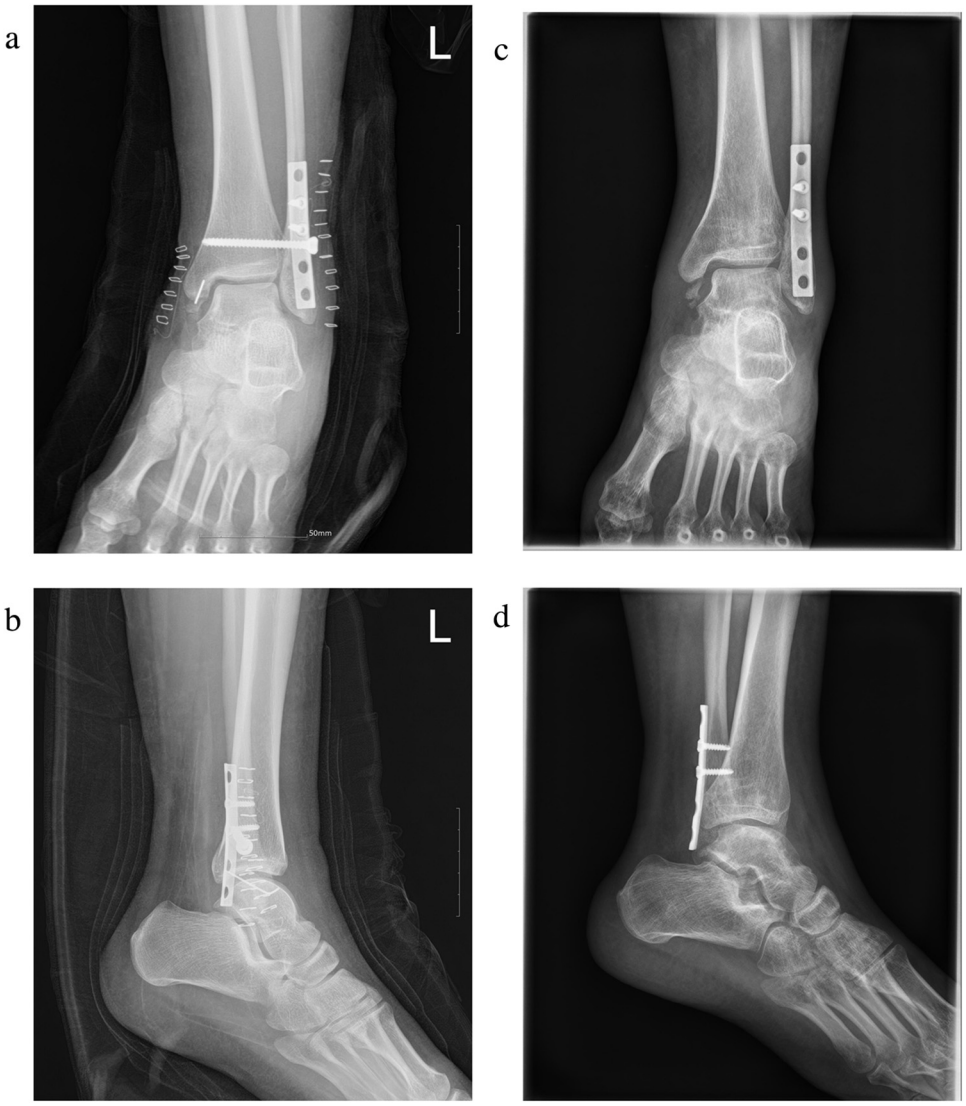

Fig. 2. Postoperative radiographs show (a-b) the normal ankle mortise and lateral fibular position following open reduction and internal fixation. (c-d) The mortise and lateral ankle radiographs on 1 year follow-up. Medial joint spaces were slightly widened in the mortise view.

before surgery, but underwent emergency surgery (<24 h) because of severe dislocation or swelling, and were consequently categorized into group A.

Overall, 29 of 51 (56.86%) patients were diagnosed as having Bosworth fracture-dislocation preoperatively, whereas 22 of 51 (43.14%) patients did not have such preoperative diagnosis. Some of the cases were misdiagnosed as simple ankle fractures with instability or fracture-dislocation preoperatively. Of 22 (preoperatively unrecognized) cases, 10 were diagnosed as Bosworth fracture-dislocation during the surgery, when it was observed that the dislocated fibula was fixed behind the posterior tibia. The remaining 12 cases were not recognized as Bosworth fracture-dislocations during surgery but were diagnosed as Bosworth fracture-dislocations in this review (Table 1).

The mean length of stay was 15.75 (standard deviation [SD], 0.680) days in group A and 21.20 (SD, 1.528) days in group B. The cause of the injury was falling down stairs in 27 (52.94%), a traffic accident in 14 (27.45%), falling from a height in 6 (11.76%), and other reasons in 4 (7.84%) patients. Thirty-six patients met the criterion for inclusion in group A, including 34 (94.44%) who underwent a 1-staged operation and 2 (5.56%) who underwent a 2-staged operation. Group B consisted of 15 patients, including 5

Table 1
Demographic data of patients groups underwent urgent surgery (Group A) and underwent surgery after 24 h (Group B).

Variable	Group A	Group B	*P*-value
No. of patients	36	15	1.000
Age at surgery, years	35.97 ± 1.643 (Range, 21–55)	34.33 ± 2.296 (Range, 22–54)	.541
Mean body weight	65.7 (57–79)	68.3 (55–83)	.365
Sex, male	24 (66.67%)	8 (53.33%)	.370
Affected leg, right	17	9	.406
Time from the injury to surgery, hours	13.78 ± 5.094 (Range, 5–23)	53.93 ± 18.626 (Range, 29–92)	<.00*

* The difference is significant ($P < .05$).

(33.33%) who underwent a 1-staged operation and 10 (66.67%) who underwent a 2-staged operation. Two-staged operations were performed for severe swelling or soft tissue injuries. The first operation involved closed (n = 3) or open (n = 9) reduction and external fixation, and the second operation was performed after the swelling and soft tissue injuries were decreased. Furthermore, in multivariate logistic regression, the odds ratio (95% confidence interval) of the 2-staged operation of group B compared with group A was 45.743 (6.036–346.654).

Concerning postoperative complications, 6 (16.67%) patients in group A had wound complications, versus 4 (26.67%) patients with acute complications in group B, including wound complications (n = 2) and fasciotomy for compartment syndrome (n = 2). Approximately 8 h postoperatively, both cases were diagnosed as compartment syndrome with severe pain and paresthesia of the foot, and a fasciotomy was performed. In addition, there were 6 cases of subacute and chronic complications in group A, including osteoarthritis (n = 3) and mal-union (n = 3), and 5 cases of subacute and chronic complications in group B, including osteoarthritis (n = 3) and mal-union (n = 2). None of the patients in either group underwent reoperation for non-union or metal failure (Table 2).

The associated medial lesions were malleolus fracture and deltoid ligament injury, with 28 and 22 cases, respectively. The associated tibial fractures were 9 Tillaux-Chaput fragments, 2 Wagstaffe Le Fort fragments, and 29 Volkman fragments (Table 3).

The mean AOFAS outcome score was 82.14 (SD, 1.667) in group A and 74.53 (SD, 1.907) in group B. The AOFAS outcome score at 1 year postoperatively was significantly better in group A than in group B (Fig. 3).

4. Discussion

Bosworth fracture-dislocation, which is the term used to describe a type of fracture and dislocation in which the dislocated fibula is fixed to the posterior malleolus [1]. This type of fracture-dislocation was first described as a specific clinical entity by Bosworth in 1947 [1,4]. Bosworth fracture-dislocation of the ankle is a rare injury that is frequently missed [1,5,6]. This may be why its true prevalence is imprecise. This diagnosis should always be kept in mind in cases of fracture-dislocation of the ankle. Although reported to be rare in most studies, the actual prevalence of Bosworth fracture-dislocations has not been evaluated.

We found that the prevalence of Bosworth fracture-dislocations (n = 51) was 1.62% among patients with ankle fractures who were enrolled in this study (n = 3140). The preoperative diagnostic rate of Bosworth fracture-dislocation at 4 university hospitals before surgery was only 56.86% (29 of 51). Some cases were diagnosed intraoperatively and 12 (23.53%) cases that were not diagnosed during surgery were diagnosed as Bosworth fracture-dislocations in this review study. Indeed, the understanding and treatment of Bosworth fracture-dislocations are lacking.

The most commonly described injury mechanism resulting in a Bosworth injury is twisting, often classified as a Lauge-Hansen supination-external rotation (SER)-type fracture and associated with Danis-Weber B fractures [2,7,8]. In our study, the ratio of Bosworth fracture-dislocations (n = 51) in only SER-type ankle fractures (n = 1589) was 3.21%. Bosworth fracture-dislocations (n = 51) were classified as Danis–Weber type A in 1 patient, B in 48 patients, and C in 2 patients.

The history of injury seems to show a correlation with the Bosworth fracture-dislocation injury mechanism. An external rotation force applied to a supinated foot after dividing the anterior and posterior tibiofibular ligament produced the following injuries. The anteromedial part of the capsule ruptured first, followed by the interosseous ligament. The interosseous membrane then tore at a point 4–6 cm proximal to the ankle mortise. As external rotation continued, the fibula was pulled posteriorly by the intact lateral ligament complex (mainly the posterior talofibular ligament) of the ankle and became entrapped behind the posterolateral ridge of the tibia. Posterior tibial fracture (Volkman fragment) can occur during the dislocation. As the talus continued to rotate around the intact deltoid ligament and medial malleolus, the fibula fractured in the pattern of SER. The final stage of injury was a fracture of the medial malleolus or rupture of the deltoid ligament [4,6,9]. Our studies show that 22 cases were associated with deltoid ligament rupture; and 28, with medial malleolus fracture. On the lateral side, the anterior tibiofibular ligament can be ruptured or avulsed with a fragment of bone from the anterior tibial tubercle (Tillaux-Chaput) or anterior fibular tubercle (Wagstaffe), in addition to posterior dislocation of the fibula together with the talus. In this study, we had 9 cases of anterior tibial fracture and 2 cases of anterior fibular tubercle avulsion fracture. Previous studies [2,3,9–13] provide limited information on the associated injury pattern (Table 3). More data are needed to establish statistical evidence for the understanding the associated injury of Bosworth fractures.

Bosworth fracture-dislocations are often unrecognized on initial radiographic imaging. The typical radiographic appearances of a widened medial joint space and the posterior position of the fibula can be misinterpreted and incorrectly attributed to poor radiographic projections. However, even skilled surgeons often have difficulties in making a diagnosis based on simple radiographs. Some radiographic imaging methods can be helpful in radiographic imaging because CT often cannot be performed immediately.

Standard anteroposterior, lateral, both oblique and mortise radiographs should be taken in patients suspected of having ankle fractures. Raising awareness of the Bosworth variant and its characteristic radiographic features, including overlap of the proximal fibular fragment and the distal tibia on anteroposterior view, and posterior displacement of the fibula on the lateral view would help avoid misdiagnosis. The axilla sign is a radiographic marker that can be used to identify patients with Bosworth fracture-dislocations of the distal fibula on mortise view of plain radiographs. A radiographic axilla of the medial tibial plafond is visible on radiographs owing to internal rotation of the tibia when the fibula is dislocated posteriorly to the tibia [10]. It seems to be associated with a rupture of the anteromedial part of the capsule and a rupture of the deltoid ligament, or a fracture of the medial malleolus. In addition, measuring the fibular position in relation to the talar body in external oblique radiographs provides useful information that can differentiate Bosworth-type fractures from other reducible bimalleolar fractures [3]. The fibula is positioned in the middle of the talar body on external oblique radiographs of Bosworth-type ankle fractures.

It could be difficult to diagnose the injury even when using these 2 methods unless it is done by a skilled physician. Therefore, it is necessary to routinely take CT images as early as possible and to identify Bosworth fracture-dislocations in an axial slice view. A CT scan may prove helpful in identifying the Bosworth variant, associated soft tissue injuries and aiding preoperative planning [6,7].

Table 2
Comparison of results between the A and B groups.

	Group A (n = 36)	Group B (n = 15)	*P*-value
Length of stay, days	15.75 ± 0.680	21.20 ± 1.528	.001*
One stage operation	34(94.44%)	5(33.33%)	<.001*
Complication	12(33.33%)	9(0.60%)	.188
Acute	6(16.67%)	4(26.67%)	
Subacute or chronic	6(16.67%)	5(33.33%)	

* The difference is significant ($P < .05$).

Table 3
Associate Injury pattern.

Authors	Number of cases	Medial malleolus fracture	Deltoid ligament injury	Tillaux-Chaput fragment	Wagstaffe fragment	Volkman fragment
Our Study	51	28	22	9	2	29
Yang et al. [3]	4	3	1	0	0	0
Khan et al. [10]	1	0	0	0	0	1
Williams et al. [11]	1	0	0	0	0	0
Cho et al. [12]	15	13	2	3	0	9
Schepers et al. [2]	1	0	1	0	0	1
Collins et al. [13]	1	0	1	0	0	0
Bartonicek et al. [9]	6	2	4	3	0	5
Total	80	46	31	15	2	45

Closed reduction is usually attempted in cases of fracture-dislocation of the ankle to minimize further risks of skin impingement and necrosis, but often unsuccessful in Bosworth fracture-dislocations. In some types of fracture-dislocation of the ankle, it is usually easy to reduce the ankle manually. However, in Bosworth fracture-dislocations, the dislocation is rather rigid and a satisfactory closed reduction of the ankle cannot usually be achieved because the posterolateral ridge of the tibia may prevent anatomic reduction. Forceful closed reduction of the dislocated ankle or repeated attempts are not advisable, because these can cause additional soft tissue trauma, especially around the fibula. Gentle reduction may occasionally be attempted; however, it is advisable for patients to undergo emergency surgery.

Compared with universal ankle fractures, Bosworth fracture-dislocations have a higher incidence of complications, including compartment syndrome, avascular necrosis of the talus, and osteoarthritis of the ankle [6,8,14,15]. Some researchers have reported that delaying surgery could result in ankle ankyloses or have an effect on the joint that could result in future arthritis [1,16]. And, delays in reducing the ankle may result in a stiff ankle, which can have capsular and extra-capsular pathologies [17,18].

The detrimental effect of surgery to the associated soft tissue injury could cause issues with wound healing and infection [9]. Most patients admitted with Bosworth fracture-dislocation often show severe soft tissue swelling. We have observed 2 cases in group A in which internal fixation could not be applied to the dislocated fibula after an open reduction because of severe swelling. An external fixation was needed instead, and a 2-staged operation was performed. Generally, surgery is delayed until swelling is reduced in patients with ankle fractures with severe swelling. However, delaying surgery in cases of Bosworth fracture-dislocation has no benefits, and swelling may continue or worsen. It is probable that more 2-staged operations or external fixations were done in group B. Swelling in these cases did not improve with time. The mal-union or osteoarthritis rate in group B was also higher, which may suggest that the surgery might have become more difficult due to the delay. Urgent surgery may help decrease the risk for posttraumatic arthritis, and an accurate diagnosis before the surgery could result in a smoother and more precise surgery [5,9]. Early diagnosis and reduction of ankle dislocation are important to minimize subsequent complications [16,19]. This study also demonstrates that the outcomes were unfavorable in patients whose surgeries were delayed due to unrecognized fracture or other reasons. The lower AOFAS scores in group B may indicate that early diagnosis and treatment of the dislocation were not done and ultimately had an adverse effect on the joint.

We acknowledge that this study has some limitations owing to the small number of included patients. In addition, it is probable that the relatively low difference of complications between the 2 groups was due to the bias caused by some patients in group A

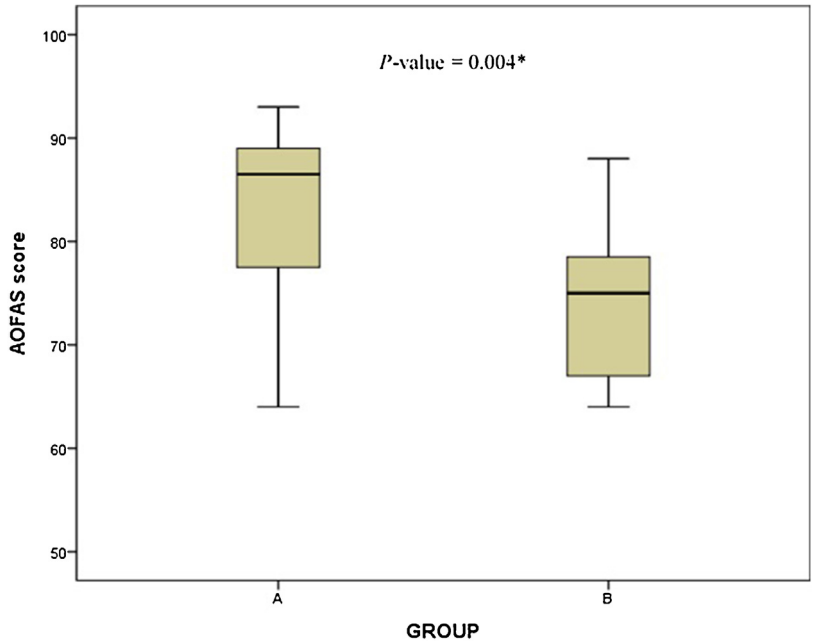

Fig. 3. Comparison of AOFAS score between group A and B in 1-year postoperatively. (*The difference is significant (P < .05). AOFAS; American Orthopedic Foot and Ankle Society).

having undergone urgent surgery because they had more severe dislocation or instability. The 1-year postoperative AOFAS score results showed that group B might have relatively severe ankyloses and significantly reduced the range of motion. Thus, early surgery and fixation are advisable. However, an ideal time or surgical method has yet to be established for patients with Bosworth fracture-dislocations. Additional studies are needed to determine a suitable surgical treatment method in these patients.

5. Conclusion

We found a rather high prevalence of Bosworth fractures in this multicenter study, and this type of fracture is often missed. In addition, outcomes may be poor if patients are not promptly treated with early reduction or surgery. Thus, early, precise diagnosis and early treatment are critical for patients with an ankle fracture, especially those with Bosworth fracture-dislocations.

Acknowledgment

None.

Conflict of interest

None.

References

[1] Bosworth DM. Fracture-dislocation of the ankle with fixed displacement of the fibula behind the tibia. J Bone Joint Surg Am 1947;29:130–5.
[2] Schepers T, Hagenaars T, Den Hartog D. An irreducible ankle fracture dislocation: the Bosworth injury. J Foot Ankle Surg 2012;51:501–3.
[3] Yang KH, Won Y, Lim J-R, Kang D-H. Assessment of Bosworth-type fracture by external oblique radiographs. Am J Emerg Med 2014;32:1387–90.
[4] Perry CR, Rice S, Rao A, Burdge R. Posterior fracture-dislocation of the distal part of the fibula. Mechanism and staging of injury. J Bone Joint Surg Am 1983;65:1149–57.
[5] White SP, Pallister I. Fracture-dislocation of the ankle with fixed displacement of the fibula behind the tibia — a rare variant. Injury 2002;33:292–4.
[6] Bartoníček J, Rammelt S, Kostlivý K. Bosworth fracture: a report of two atypical cases and literature review of 108 cases. Fuß Sprunggelenk 2017;15:126–37.
[7] Wright SE, Legg A, Davies MB. A contemporary approach to the management of a Bosworth injury. Injury 2012;43:252–3.
[8] Downey MW, Motley T, Kosmopoulos V. The Bosworth ankle fracture: a retrospective case series and literature review. EC Orthop 2016;3:243–53.
[9] Bartonicek J, Fric V, Svatos F, Lunacek L. Bosworth-type fibular entrapment injuries of the ankle: the Bosworth lesion. A report of 6 cases and literature review. J Orthop Trauma 2007;21:710–7.
[10] Khan F, Borton D. A constant radiological sign in Bosworth's fractures: "the Axilla sign". Foot Ankle Int 2008;29:55–7.
[11] Williams AD, Blue M, Douthit C, Caroom C. Bosworth dislocation without associated fracture. Case Rep Orthop 2018;2018:.
[12] Cho B-K, Choi S-M, Shin Y-D. Prognostic factors for intermediate-term clinical outcomes following Bosworth fractures of the ankle joint. Foot Ankle Surg 2018 (in press).
[13] Collins RS, O'connor D, Denton JR. An irreducible distal fibula dislocation while in-line skating. J Orthop Trauma 1998;12:364–6.
[14] Beekman R, Watson JT. Bosworth fracture-dislocation and resultant compartment syndrome. JBJS Case Connect 2003;2211–4.
[15] Hockenbury RT, Friermood TG. Dislocation of the distal tibiofibular joint. J Orthop Trauma 1992;6:120–4.
[16] Lui TH, Chan KB, Kong CC, Ngai WK. Ankle stiffness after Bosworth fracture dislocation of the ankle. Arch Orthop Trauma Surg 2008;128:49–53.
[17] Höiness P, Engebretsen L, Strömsöe K. Soft tissue problems in ankle fractures treated surgically: a prospective study of 154 consecutive closed ankle fractures. Injury 2003;34:928–31.
[18] Thordarson DB. Complications after treatment of tibial pilon fractures: prevention and management strategies. J Am Acad Orthop Surg 2000;8:253–65.
[19] Delasotta LA, Hansen 3rd RH, Sands AK. Surgical management of the posterior fibula fracture dislocation: case report. Foot Ankle Int 2013;34:1443–6.