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Case Study

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Unlocking the Complexity of Bosworth Fracture-Dislocations: A Comprehensive Review and Case Analysis

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ABSTRACT

The Bosworth Fracture (BF) dislocation is a rare but serious ankle injury that remains a significant diagnostic and therapeutic challenge. First described by David March Bosworth in 1947, this condition is characterized by the entrapment of the fractured fibula behind the tibia, resulting in a locked ankle. Despite its rarity, BF is often misdiagnosed or mistaken for more common ankle fractures, leading to inadequate treatment and poor outcomes. This literature review, combined with a case study from our institution, aims to focus on the complexities of BF, emphasizing the importance of early recognition and appropriate management to prevent complications.

BF can present in various forms, with the classic transsyndesmotic (Weber B) fracture being the most common. However, suprasyndesmotic (Weber C) fractures and associations with Maisonneuve fractures have also been documented. The injury mechanism typically involves an external rotation force on a supinated foot, causing the fibula to become trapped behind the tibia. This displacement is a key differentiating factor from other ankle injuries and necessitates a high index of suspicion for accurate diagnosis.

Advanced imaging, particularly Computed Tomography (CT) with 3D reconstructions, is important for diagnosing BF and planning surgical treatment. The primary goal of treatment is to restore ankle stability and congruence through meticulous reduction and fixation of all fracture components. Early intervention, typically through Open Reduction and Internal Fixation (ORIF), is essential to avoid further soft tissue damage and neurovascular complications.

This case study brings out the importance of recognizing BF as a distinct clinical entity. Increased awareness and understanding among clinicians are vital for improving patient outcomes, as timely and modified treatment can significantly reduce the risk of long-term disability. Future research should focus on larger patient cohorts and long-term follow-up to further refine management strategies for this complex injury.

Keywords: Bosworth fracture; Ankle injury; Open reduction internal fixation; Computed tomography; Diagnostic challenge; Syndesmotic instability

INTRODUCTION

In 1947, David March Bosworth (1897-1979) pioneered the description of ankle fracture-dislocations, a type of injury characterized by displacement of a fragment of the fractured fibula from the fibular notch behind the posterior surface of the distal tibia [1,2]. This initial description, based on five cases, emphasized the importance of proper diagnosis to avoid

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unfavorable outcomes in affected patients, Bosworth Fracture (BF) presents a rare but severe injury that is still frequently misjudged even today, potentially leading to severe complications [3]. The aim of the following review is to raise awareness of this injury, and its potential complications thought a report of the first case report in our hospital.

Definition

Bosworth initially described an ankle fracture-dislocation where the fibular fracture begins at the joint line level (Transsyndesmotic; Weber B; AO 4.4.B), with the proximal fragment of the fibula becoming trapped behind the posterior aspect of the tibia [2]. However, since that initial description, numerous variations have been documented. In 1984, Hammilton described a fracture of the fibula occurring between its proximal and middle thirds, (Suprasyndesmotic, Weber type C, AO 4.4) [4]. Later, in 1995, Chan et al., reported a 'Bosworth dislocation' associated with a Maisonneuve Fracture (MF). Until 2014, all BFs were classified as ankle fracture dislocations [5]. Petersen et al., detailed a Bosworth displacement of the fibular fragment in a partial fracture of the anterior portion of the tibial pilon [6]. Subsequently, Capuccio et al., documented a BF occurring alongside a partial posteromedial pilon fracture. Given that this fracture can manifest in various forms, it is essential for clinicians to maintain a high index of suspicion and be well-versed in the different presentations of this injury to ensure optimal patient management [7].

Mechanism

The mechanism of this injury was described by Bosworth in his original article: "As the foot twists under the talus, with the leg continuing to push forward and rotate outward, the lateral collateral ligaments draw the intact fibula behind the tibia [8]. Continuation of the force rotating the talus backward and out from its position beneath the tibia causes further force on the lateral collateral ligaments; finally, the fibula is broken off against the posterior tibial border". In the literature, the most frequently referenced concept of the BF mechanism highlighting external rotation in a supinated foot as the predominant mechanism of injury was published by Perry et al., in 1983.

Pathoanatomy

The BF represents a complex injury that involves several structures within the ankle joint. A defining characteristic of this condition is the displacement of the fractured fibula, which shifts from its normal alignment, moving behind the posterior aspect of the distal tibia. This displacement is a key feature that differentiates BF from other types of ankle injuries, highlighting the need for careful evaluation and management.

Fibula fracture: A 'classic' BF is typically linked to a Weber type B fracture, this injury pattern is the most commonly reported in the literature, appearing in 168 cases (94%). In contrast, a Weber type C fracture of the fibula is much less frequently associated with BF, with only 11 cases (6%) documented [1].

Medial ankle injuries: These injuries often involve either a rupture of the deltoid ligament or a fracture of the medial malleolus, which is typically bicollicular. On rare occasions, however, the medial structures remain intact [9].

Posterior malleolus: A fracture involving the distal posterior border of the tibia was initially noted by Bosworth and subsequently explored in greater detail by various other authors [1,10]. The first comprehensive analysis of the incidence and morphology of Posterior Malleolus (PM) fractures associated with BF was conducted by Kostlivý et al., with their findings published as recently. Out of 97 cases of BF documented in the literature and confirmed through radiological evidence, PM fractures were identified in 61 cases (63%) [11].

Anterior Tibio Fibular Ligamente (ATFL): Injury to the ATFL is a typical component of BF. A bony equivalent of ATFL injury is an avulsion or fracture of its insertions. A fracture of the anterolateral distal tibia (Tillaux–Chaput tubercle, anterior malleolus) Cho et al., found a fractured Tillaux–Chaput tubercle in 20% (3/15) of their patients with BF [12]. A fracture of the Wagstaffe tubercle, i.e. avulsion of the ATFL from the distal fibula, was recorded by delasota [13].

Associated injuries: Osteochondral fracture of the talus associated with BF, osteochondral fracture of the tibial pilon, and osteochondral fragments within the joint cavity were observed. Additionally, a loose intercalary fragment of the PM and displaced into the joint cavity. The interposition of the extensor hallucis longus and the extensor digitorum longus between the tibia and fibula was also described [13].

CASE PRESENTATION

A 33-year-old man sustained an injury while descending stairs and slipping, resulting in a mechanism external rotation in a supinated foot. Immediately after the injury the patient experienced sharp pain in patient's left foot and ankle and was unable to walk. Upon physical examination, visual inspection reveals a marked external rotation and posterior dislocation of the foot, with tenting of the skin without open wound. X-rays revealed a posterior dislocation of the talus in relation to the tibia and an oblique fracture of the fibula (Weber B) (Figure 1).

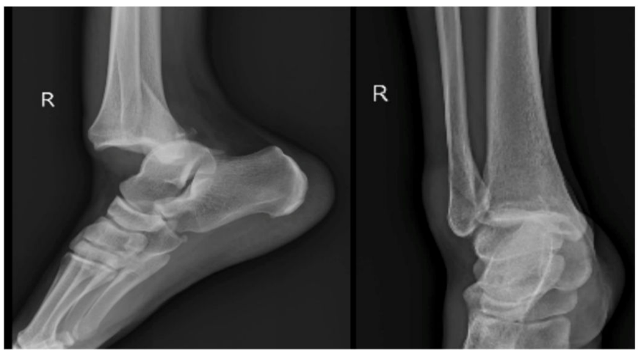

Figure 1: Anterior-to-Posterior and lateral radiography of Bosworth fracture in the right ankle.

The presence of a BF dislocation was suggested by overlap of the tibia and the proximal fragment of the fibula in the anteroposterior view, posterior luxation of the talus and tibiofibular dissociation in the lateral view. An immediate closed reduction was performed under sedation. After the reduction, patient's foot exhibited normal sensitivity and adequate capillary response, leading to the application of a cast and a subsequent CT scan of the ankle. Scan showed that the position of the fibula in the tibial groove was not restored (Figure 2).

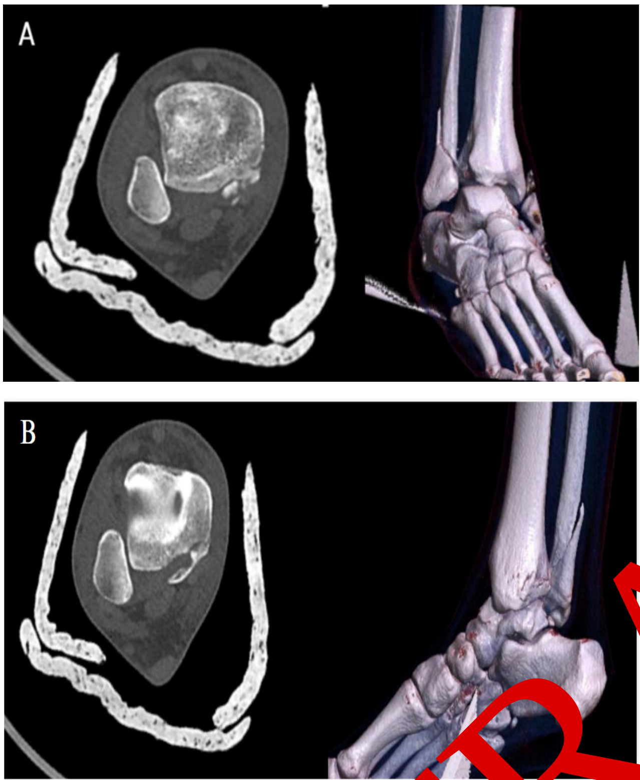

Figure 2: CT scan showed that the position of the fibula in the tibial groove was not restored after reduction and 3D reconstruction of the Bosworth fracture. (A) Front view (B) Side view.

The results of CT confirmed a proper diagnosis of a BF, they also showed failure of reduction. A BM fracture representing type I of the Bartonicek-Rammelt classification prompting the decision to admit him to the orthopedic department for an open reduction and internal fixation of the fracture [14]. Three hours post-trauma, the patient underwent surgery under general anesthesia. Two approaches were used during surgery; a posterolateral approach to the ankle for the reduction of the fracture-dislocation and a medial approach for capsular and deltoid repair.

During exposure, it was evident that the proximal part of the fracture was trapped behind the posterolateral edge of the distal tibia. The reduction of the proximal fibula was achieved by applying anterolateral pressure on the proximal fibula. The fibular fracture was fixed using a 2.5 mm lag screw and a one-third tubular plate for protection. The syndesmosis was stressed under fluoroscopic guidance and found to be unstable (positive cotton test). Consequently, it was reduced and secured with an implant syndesmosis system (TightRope® XP). A medial approach was used for severe capsular and deltoid repair with bone denudation, using two Corkscrew® suture anchors (Figure 3).

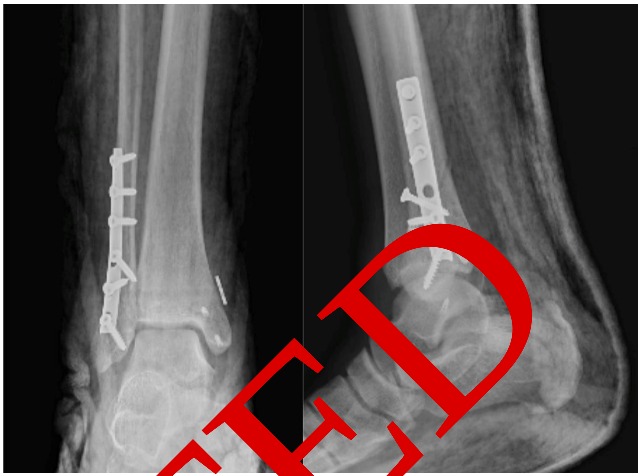

Figure 3: Final resolution of Bosworth fracture.

Postoperative treatment included immobilization with a below-knee cast for 2 weeks, followed by a transition to a walking boot with partial weight-bearing for 2 weeks. The surgical wounds healed uneventfully. The outcome was favorable, with radiological consolidation of the fracture observed at 8 weeks. At that time, the syndesmotic system was removed (Figure 4).

Figure 4: Postoperative control at 8 weeks following removal of the suspension system.

RESULTS AND DISCUSSION

The BF, described in 1947 has been recognized as a rare pattern of ankle fracture. Despite being considered rare; the prevalence of BF dislocations was not negligible [1]. A study led by Won Y et al., revealed that out of 3405 hospital admissions for ankle fractures, 51 cases corresponded to this specific type of injury, representing a prevalence of 1.62% among this patient population [15]. According to the study by Lucenti et al., this fracture was primarily observed in men with an average age of 38.8 years [10]. The traumatic mechanism was analyzed, revealing that in 58.2% of cases, the fracture resulted from accidental trauma (such as falls from height or accidents while descending stairs), 18.4% were due to sports-related injuries, another 18.4% to traffic incidents, 0.97% to work-related injuries, and 3.9% to unspecified causes. The mechanism of this injury was described 1983 by Perry et al., in his cadaveric study mention a mechanism of external rotation force while the foot is in supination causes this fracture-dislocation [16]. In his article mentions that the process is described in stages, starting with the displacement of the fibula posteriorly out of the fibular notch, leading to the rupture of the anterior and posterior tibiofibular ligaments. Subsequently, the anteromedial capsule ruptures, the interosseous membrane tears, and the fibula becomes entrapped. Additional rotation of the talus results in an oblique fracture of the fibula and, finally, a fracture of the medial malleolus or rupture of the deltoid ligament. Moerenhout et al., proposed an additional stage linking a BF with a talar fracture [17].

Recognizing the type of fracture, the fracture mechanism, and the epidemiology is important in orthopedic and trauma care because, despite the low frequency of certain fractures, the consequences of complications and achieving optimal functionality heavily depend on accurate diagnosis, treatment, and management.

Clinical examination of BF is like what is observed in other ankle fractures and fracture-dislocations. Upon visual inspection, there may be noticeable external rotation and/or posterior dislocation of the foot, potentially accompanied by skin tenting or the presence of open wounds. It is important to palpate the entire length of the fibula, as BF can be linked to a proximal or sub capital fracture of the fibula [18]. It appears to be especially susceptible to neurovascular and soft tissue complications, that why regular monitoring of the soft tissues and neurovascular status of the foot is essential, as BF increases the risk of neurovascular compromise and the potential development of compartment syndrome [19].

The standard radiographic evaluation of the ankle consists of anteroposterior, mortise, and lateral views. If a M[illegible] is suspected, additional anteroposterior and lateral radiographs of the entire lower leg, including the knee joint, should be performed [illegible].

Radiographic sing described by Khan et al., suggested that the BF could be identified by the "Axilla sign" on X-rays [20]. This finding seen on anterior posterior mortise radiographic view showing cortical density in the axilla of the medial tibial plafond and this should alert surgeons to the possibility of a BF. In the study by Lucenti et al., this axilla sign was observed in only 8.7% of patients [10]. Additionally, Yang et al., suggested including an external oblique ankle radiograph to assess the position of the fibular axis relative to the talus [21]. CT scans, including 3D reconstructions, should be considered the diagnostic gold standard for BF, as they offer a comprehensive view of the pathoanatomy [22]. They can reveal the displacement of the fibular fragment from the fibular notch, which is important for confirming the diagnosis of BF, especially in Weber type C fibular fractures, it also identifies the type of PM fracture, the entrapment of the fibular fragment between the posterior tibia and the displaced PM, as well as fractures of the Tillaux–Chaput and/or Wagstaffe tubercle, which may not be apparent on standard X-rays. Additionally, it can detect osteochondral fractures of the talus and loose intraarticular fragments [13].

Understanding all factors around this fracture allows clinicians to make informed therapeutic decisions, modified interventions to the patient's specific needs and anticipate potential complications. Knowledge about al pit falls is essential for ensuring proper healing, minimizing the risk of long-term disability and improving the overall quality of life for the patient. In a study made my Won et al., demonstrated that an unrecognized a BF, can result in inappropriate treatment and permanent disability [15]. With accurate diagnosis and prompt treatment, excellent results can usually be obtained.

Current concepts about BF emphasize standard treatment approach involves early open reduction and internal fixation [2]. In most cases, BF is significantly displaced, heightening the risk of additional soft tissue damage and neurovascular complications. If immediate surgery is not possible, it is essential to attempt to reduce the fracture, especially by repositioning the displaced fibula back into the fibular notch. However, attempts at closed reduction are often unsuccessful [7]. While radiographs may indicate an improved alignment of the subluxed talus relative to the tibia and a better relationship between the talar dome and the medial malleolus, the locked displacement of the fibular fragment from the fibular notch and the resulting tibiofibular dissociation typically remain unresolved. Therefore, the standard treatment procedure involves early open reduction and internal fixation. In a study it was mentioned that only three out of 103 patients (2.9%) benefited from a successful closed reduction [10]. The recommended maneuver for reduction is to apply direct manual pressure on the proximal fibular fragment from behind, while simultaneously performing internal rotation of the foot [23]. However, there are authors who oppose closed reduction, as it can cause damage to the soft tissues [19,24]. Other soft tissue complications associated with BF include skin necrosis, infection, and ankle stiffness, particularly after delayed reduction or deep peroneal palsy after repeated reductions [10,17-19,24]. In the most recent literature, there are descriptions of reduction using percutaneous pins as detailed by Patel et al., with success and good outcomes [25].

The surgical approach is tailored to the specific pathoanatomy of the fracture. The first essential step is to reduce the entrapped fibular fragment, is important to careful revision of the joint cavity and removal of all loose osteochondral fragments. Following this, if indicated, reduction and fixation of the PM should be performed [10,19]. Generally, reduction and fixation are advised for Bartonicek and Rammelt types II–IV PM fractures that involve displacement, intercalary fragments, or tibial plafond impaction. Successfully reducing and fixing displaced PM fragments will help restore the fibular notch and stabilize the posterior syndesmosis. The preferred method for reducing the fibula into the fibular notch and subsequently reducing and fixing the fractured PM is through the posterolateral approach [2]. Anatomic reduction of the PM is verified using lateral fluoroscopic views. Only after this confirmation is reduction and internal fixation of Weber type B fibular fractures carried out as a third step, utilizing the same surgical approach. Fractures of the medial malleolus can be addressed through a medial approach, either before or after the internal fixation of the fibula. In a systematic review, it was found that open reduction and internal fixation (using a plate and screws on the fibula in 93.3% of cases) [10]. The deltoid ligament is examined only if there is persistent widening of the medial clear space or a spontaneous valgus tilt of the talus [2]. In the fourth a last step, the stability of the tibiofibular mortise is assessed through stress testing after all fractures and bony avulsions have been fixed. If any residual instability is detected, it is managed by inserting a syndesmotic screw or a flexible implant in cases of syndesmotic instability, its fixation is necessary, as observed in 30.1% [2,16]. The sequence of reduction is continuously controlled with an image intensifier. Further, postoperative management aims at functional rehabilitation under protected weight-bearing. Post-surgical complications included post-traumatic ankle arthritis, which occurred in 10.7% of patients, followed by wound complications (7.7%), defective consolidation (4.8%), and painful joint stiffness during dorsiflexion and plantar flexion (5.8%) [10].

The outcomes of surgical treatment are varied. Many studies, particularly earlier ones, report persistent pain even after a short period, along with limitations in range of motion or even ankle joint stiffness, and the development of degenerative changes. This may be due to the complex nature of the injury, often involving significant soft tissue trauma. Larger studies have shown significantly better one-year results when early reduction is performed compared to delayed surgery (beyond 24 hours) [15]. Factors that contribute to poorer outcomes include the severity of the injury, such as the presence of a partial pilon fracture and unsuccessful closed reduction of the fibula [12].

Case analysis

This case involves a 33-year-old male who sustained a BF dislocation while descending stairs, a rare and severe type of ankle injury characterized by the entrapment of the fibula behind the tibia. The mechanism of injury involved external rotation in a supinated foot, leading to an oblique fibular fracture (Weber B) and posterior dislocation of the talus. This clinical presentation aligns with the descriptions found in the literature, where external rotation forces on a supinated foot are highlighted as a common mechanism for BF. Upon physical examination, the patient exhibited significant external rotation and posterior dislocation of the foot, with visible skin tenting but no open wound. These findings are consistent with the typical clinical signs of BF, where severe deformity and difficulty in closed reduction are common. The initial X-rays suggested a BF through the overlap of the tibia and the proximal fragment of the fibula, coupled with posterior talus luxation and tibiofibular dissociation. This radiographic presentation is important, as the overlap sign is a key indicator of BF, as reported in various studies. A subsequent CT scan confirmed the diagnosis of BF and revealed the failure of the initial closed reduction attempt, which is a well-documented challenge in managing BF due to the fibula's entrapment. Additionally, the CT scan identified a PM fracture, classified as type I in the Bartonicek-Rammelt classification.

The surgical approach involved two incisions: A posterolateral approach to reduce the fracture-dislocation and a medial approach for repairing the capsular and Deltoid structures. This dual approach is supported by the literature, which emphasizes the need for precise reduction of the fibula and repair of associated injuries to restore ankle stability. The fibular reduction was achieved through direct manipulation, and the fracture was stabilized with a lag screw and a tubular plate. The unstable syndesmosis, confirmed by the Cotton test, was secured with a TightRope® XP system, reflecting current best practices for managing syndesmotic injuries in BF cases. Postoperative care included immobilization and gradual weight-bearing, with radiological evidence of fracture consolidation at 8 weeks. The removal of the syndesmotic system at this stage is indicative of a successful outcome, with the patient showing no signs of complications. This case is particularly noteworthy due to the complexity of the injury, involving a rare BF coupled with a PM fracture. The failure of closed reduction and the need for advanced imaging and surgical techniques underscore the challenges associated with BF. The successful outcome, with complete fracture consolidation and restoration of function, highlights the importance of a meticulous and informed approach to treating this rare and severe injury. This case exemplifies the critical importance of early recognition and appropriate management of Bosworth fractures. The use of advanced imaging, precise surgical intervention, and comprehensive postoperative care were pivotal in achieving a favorable outcome. This case contributes to the growing body of evidence on BF and reinforces the need for heightened awareness and specialized treatment strategies in managing this challenging injury.

CONCLUSION

As the BF is a rare but particularly severe variant of locked ankle fracture-dislocation that presents unique challenges in both recognition and treatment. Unlike more common ankle fractures, the BF involves the entrapment of the fibula behind the tibia, creating a situation where the fibula is effectively locked in position. This uncommon injury pattern can easily be overlooked or misdiagnosed, leading to delayed or inappropriate treatment. The complexity and severity of BF are often underappreciated due to the low awareness and minimal experience in managing such fractures at many institutions. This lack of familiarity can result in complications and poor outcomes if the fracture is treated as a routine ankle injury.

Recognizing a BF early is critical. Clinicians should maintain a high index of suspicion, particularly in cases where there is significant deformity or when the standard closed reduction techniques fail. The characteristic of BF is the inability to reduce the fibula into its anatomical position through closed methods, which should immediately prompt consideration of this rare injury. Imaging, especially CT scans with 3D reconstructions, plays an important role in the diagnosis. These advanced imaging techniques allow for detailed visualization of the fracture components and the degree of displacement, facilitating the planning of an optimal surgical approach.

The treatment of BF requires an aggressive and well-planned approach. Early reduction of the displaced fibular fragment is essential, but repeated attempts at closed reduction should be avoided as they can exacerbate soft tissue damage and complicate subsequent surgical procedures. The primary goal of operative treatment is to restore ankle congruence and stability, which involves the meticulous reduction and fixation of all bony components of the fracture. This includes addressing displaced or impacted fractures of the posterior malleolus, the Tillaux–Chaput tubercle, and/or the Wagstaffe fragment, as well as ensuring anatomic reduction of the distal fibula into the fibular notch.

Postoperative care should include confirmation of the reduction quality through CT imaging to ensure that all fracture components are adequately addressed. Given the potential for long-term complications, such as post-traumatic arthritis, it is vital that future studies focus on larger patient cohorts and include long-term follow-up, with a minimum of five to ten years, to better understand the outcomes and refine treatment protocols.

The increased awareness and understanding of Bosworth fractures are important. They should not be mistaken for typical ankle fractures, as this can lead to suboptimal treatment and poor outcomes. Early recognition, appropriate imaging and a modified surgical approaches are key to managing this challenging injury effectively.

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