Arthroplasty Today 30 (2024) 101547

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Case Report

Periprosthetic Hip Fracture due to Ballistic Injuries

Felipe Sandoval, MD[a, b, *], Joaquin Valenzuela, MD[a, c], Maximiliano Carmona, MD[a, d], Bénjamin Guiloff, MD[a, d], Martin Salgado, MD[a, e]

[a] Department of Orthopaedic Surgery, Complejo Asistencial Sótero Del Río, Santiago, Región Metropolitana, Chile
[b] Department of Orthopaedic Surgery, Hospital de Carabineros, Santiago, Región Metropolitana, Chile
[c] Department of Orthopaedic Surgery, Clínica Universidad de los Andes, Santiago, Región Metropolitana, Chile
[d] Department of Orthopaedic Surgery, Facultad de Medicina, Pontificia Universidad Católica de Chile, Santiago, Región Metropolitana, Chile
[e] Department of Orthopaedic Surgery, Clínica MEDS, Santiago, Región Metropolitana, Chile

ARTICLE INFO

Article history:
Received 31 July 2024
Received in revised form
17 September 2024
Accepted 18 September 2024
Available online xxx

Keywords:
Gunshot wound
Total hip arthroplasty
Periprosthetic fracture
Open fracture
Case report
Ballistic injury

ABSTRACT

Periprosthetic hip fractures are a common cause for revision. To date, however, there are no reports of periprosthetic fractures (PFs) in total hip arthroplasty caused by ballistic injury (BI). There are no current recommendations on the management of this pathology in the literature. The objective of this paper is to report on 2 successfully treated cases of PF caused by BIs. Additionally, a brief review of the literature regarding open fracture secondary to BIs is carried out. What we consider appropriate initial and definitive management for these patients is outlined. According to our clinical results and current evidence, adequate management for a BI Vancouver B1 femoral PF consists of early antibiotic therapy, surgical debridement, osteosynthesis with variable angle locking plate, structural allograft, cerclage wires, and negative pressure wound therapy.

Introduction

Periprosthetic fractures (PF) are a rising cause of total hip arthroplasty (THA) revision. National joint registries from the United States and United Kingdom showed that PFs accounted for 14%-20% of all revision indications, respectively [1,2]. Despite this, ballistic periprosthetic fractures (B-PFs) have not been previously reported. Their optimal treatment is as complex a challenge as it is unknown. Since there is no evidence or direct recommendation on B-PF, we must extrapolate their treatment from existing evidence on ballistic injuries (BIs) causing open fractures combined with conventional treatment of PFs. An evaluation must be carried out in the emergency room to categorize these injuries and thus approach them systematically. The initial orthopedic team management should be similar to an open fracture: irrigation and debridement, external or definitive fixation depending on injury type, and infection prevention [3,4].

No reports on management, infection prognosis, nonunion, or aseptic loosening in the B-PF context are available. This article's main objective is to offer a perspective on management of a B-PF by extrapolating the existing literature on gunshot fractures and PFs to this scenario. We report 2 cases of patients with B-PF successfully treated with open reduction and internal fixation.

Case histories

The Consensus-based Clinical Case Reporting Guideline Development was used. Two case reports are presented, approved by our hospital's ethics committee.

Case 1

A 33-year-old male patient with multiple social conflicts and no medical history presented to the emergency room due to a BI in the inguinal region. A fracture of the left femoral head and neck was diagnosed and initially treated with debridement and removal of bullet fragments. During initial hospitalization, the patient received 48 hours of antibiotic treatment with first-generation cephalosporins and gentamicin. However, without further treatment, the

* Corresponding author. Department of Orthopedics, Complejo Asistencial Sótero del Río, AV. Concha y Toro 3459, 8207257, Puente Alto, Santiago, Chile. Tel.: +5 695 445 9026.
E-mail address: felipesandga@gmail.com

https://doi.org/10.1016/j.artd.2024.101547

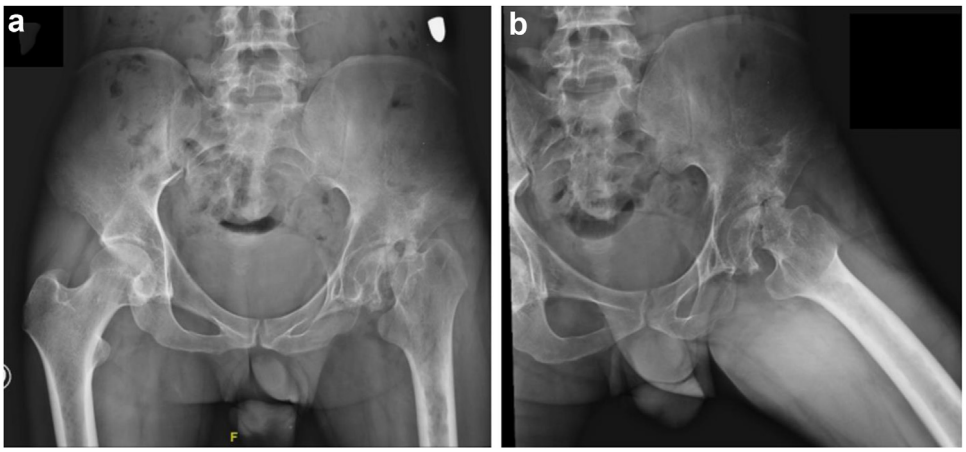

Figure 1. Preoperative pelvis anteroposterior (a) and left hip cross-table (b) radiographs two years after first ballistic surgery.

patient voluntarily left the hospital and did not attend any medical check-ups for at least 2 years, receiving no further treatment.

Two years later, he presented to the outpatient clinic complaining of left hip pain. Initial study with radiographs (Fig. 1a and b) and a computed tomography scan (CT) (Fig. 2a and b) showed avascular necrosis of the femoral head and nonunion of the femoral neck fracture. Laboratory studies showed normal complete blood count, C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR). An ultrasound study was performed to find puncturable fluid and rule out infection, but no fluid was found and 2 cultures of tissue were obtained with no pathogen growth.

After a thorough preoperative work-up, a cementless left THA (Fig. 3) was performed using a Corail stem and Pinnacle acetabular cup (Depuy Synthes, Raynham, MA) through a posterior approach. According to hospital protocols, the patient was discharged 48 hours after surgery with a satisfactory postoperative x-ray. The patient received follow-up at three- and 6-weeks post op with weight-bearing as tolerated and no daily living restrictions. He received no x-ray imaging in this period. Three months after THA, the patient arrived at the emergency room with multiple BIs in his anterior proximal right thigh, anterior proximal left thigh, right leg and abdomen. He was admitted with multiple diagnoses: open right subtrochanteric fracture, open PF with a well-fixed femoral component (Vancouver B1), open right tibia fracture, and abdominal injury with involvement of the small intestine and sigmoid colon but no injury continuity with his left hip. Physical exam showed no neurovascular compromise whatsoever. Initial emergent surgery was performed with resection of the compromised intestine and colostomy. Both femoral fractures and right leg were treated with irrigation and debridement plus external fixation (Fig. 4) in addition to intravenous antibiotic treatment with 2 g of cefazolin, 160 mg of gentamicin and 500 mg of metronidazole. Pin placement for external fixation was decided to give as much stability as possible, so a supra-acetabular pin was placed bilaterally and two pins placed in each femur. These were connected with carbon bars in a quadrangular fashion to enhance stability.

Seven days later, fixation of the right subtrochanteric fracture was performed with a cephalomedullary nail and open reduction internal fixation of the left PF. Infection at that time was not a concern as the patient had been initially well treated with irrigation, debridement, and antibiotics. The patient was positioned in a supine position on a radiolucent table. A 4.5/5.0 LCP Condylar Plate (Depuy Synthes, Raynham, MA) was used in an inverted manner. Anteromedial cortical strut allograft was used over the bone defect and fixed with proximal wires. Finally, the plate was fixed distally with one cortical and three locking screws and fixed proximally with 5 variable angle monocortical locking screws directed anteriorly and posteriorly, avoiding the femoral stem (Fig. 5) [5].

Wound closure was performed in a standard fashion and complemented with full sponge incisional negative pressure wound

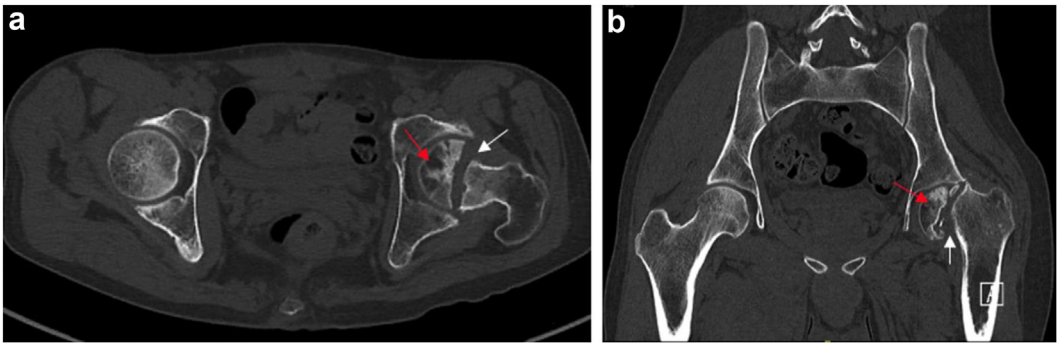

Figure 2. Preoperative (a) axial and (b) coronal images of CT scan two years after first ballistic injury showing femoral neck nonunion (white arrow) and avascular necrosis of the femoral head (red arrow). CT, computed tomography.

Figure 3. Postoperative anteroposterior pelvis radiograph of uncemented THA. THA, total hip arthroplasty.

Figure 4. Postoperative anteroposterior radiograph shows external supraacetabular fixation. Right subtrochanteric fracture and left periprosthetic fracture with an apparently stable femoral stem.

therapy. This was maintained during his entire stay. The patient progressed favorably with no wound complications during his hospital stay. He was discharged with oral 1st generation cephalosporin for 7 days as extended oral antibiotics protocol. No weight-bearing was allowed for 8 weeks. After 8 weeks, the patient was instructed to bear weight as tolerated on the right lower extremity and toe-touch weight-bearing on the left lower extremity. In week twelve, weight-bearing as tolerated was authorized. Serial blood tests were performed with CRP and ESR, which were always within normal range. Complete bone union was obtained at 5 months for the right subtrochanteric fracture and at 11 months for the left PF (Fig. 6). Until the last follow-up at 11 months, there were no unanticipated or adverse events. The patient reported a favorable result, as he was able to maintain a normal gait for long periods of time. Final CT scan to confirm bone union was unobtainable as the patient died due to nonmedical causes in a social conflict. A timeline of the patient's events is summarized in Figure 7.

Case 2

A 62-year-old man with a history of type 2 diabetes, hypertension, obesity, and a primary left THA of an undetermined number of years presented to the emergency room with a BI to his left anterior thigh and abdomen. The patient was diagnosed with a Vancouver B1 left B-PF with massive distal bone comminution (Fig. 8) and intestinal perforation.

Initial management in the ER included irrigation and debridement, external fixation of the femur fracture and systemic antibiotic therapy with cefazolin 2g, gentamicin 240 mg, and metronidazole 500 mg. No x-rays were obtained to confirm adequate positioning of external fixation in the femur. However, satisfactory supra-acetabular fixation was confirmed with a CT scan of the abdomen and pelvis requested by the general surgeon. The general surgeon performed a contained laparotomy for the initial management of his abdominal trauma. Seventy-2 hours after admission and emergency surgery, the patient underwent definitive osteosynthesis. Initially, the proximal fragment was reduced and stabilized with 1.0 mm wires. A cortical strut allograft was placed for augmentation on the medial zone bone defect and fixed with 1.0mm wires in order to "assemble the tube" prior to definitive fixation.

Finally, the 4.5/5.0 LCP Condylar Plate (Depuy Synthes, Raynham, MA) was molded to accommodate the proximal femur approximated with a distal cortical screw, then fixed to the femur with 6 distal locking screws and 3 proximal 1.7-mm wires. Fixation was supplemented proximally with 2 variable angle locking screws (Fig. 9).

During the hospital stay, a full sponge incisional negative pressure wound therapy dressing was used. This was maintained during his entire stay. He was discharged with oral 1st generation cephalosporin for 7 days as extended oral antibiotics protocol. Toe-touch weight bearing was allowed for the first 8 weeks, with no surgical wound complications whatsoever. Serial blood tests showed a progressive decline in ESR and CRP. Radiographic controls showed no loss of fixation or signs of complication. At 3 months postoperatively, the patient successfully tolerated 50% weight bearing, pain-free (Fig. 10) with no evidence of infection on laboratory exams or physical examination.

The patient died during his fourth postoperative month in a car accident. Until the last follow-up, there were no unanticipated or adverse events related to surgery. A timeline of the patient's events is summarized in Figure 11.

Discussion

There are no guidelines in literature about B-PF regarding their treatment or follow-up. As far as the authors are concerned, these are the first B-PF cases reported in literature to date, and as such, the first reported treatment proposal.

In nonmilitary settings, BIs are typically considered low energy [6] and generally do not require immediate surgery. In contrast, high-velocity gunshot wounds cause extensive soft tissue damage, often necessitating surgery for irrigation and debridement of necrotic tissue. However, definitive

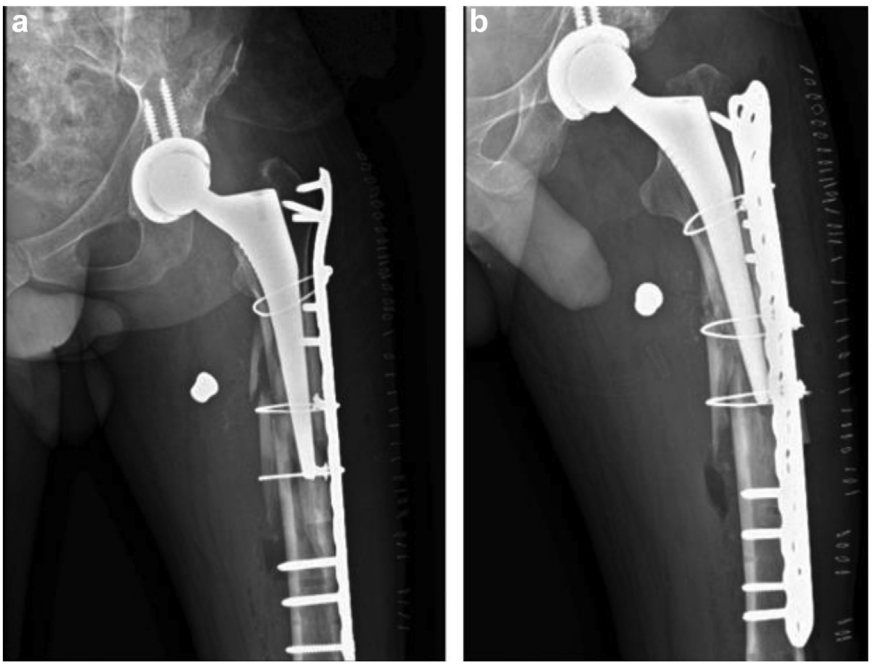

Figure 5. (a) Postoperative anteroposterior and (b) oblique proximal femur radiographs show fixation, as described. Note the unicortical screws proximally.

categorization of a gunshot fracture remains elusive. Each patient and injury must undergo individual analysis due to varying characteristics contributing to different energy levels [3]. The available evidence on irrigation and debridement in low-velocity firearm injuries is not conclusive enough to make either decision [6]. Given the uncertainty in determining the low- or high-velocity nature of the BIs in both patients, the authors opted for a precautionary approach, incorporating irrigation and debridement into the management.

Some authors support the nonadministration of antibiotics in low-energy BI fractures [7]. However, contact with clothing and skin can colonize the affected area. Also, subjects may deliberately contaminate bullets with fecal matter and other external substances before loading them into firearms, with the intent of

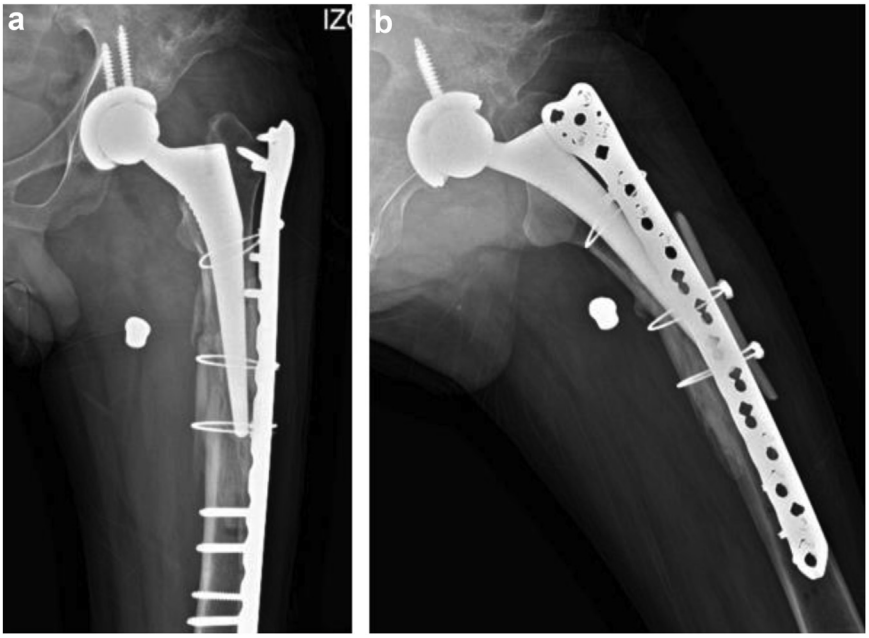

Figure 6. Postoperative (a) anteroposterior and (b) oblique proximal femur radiographs show bone union.

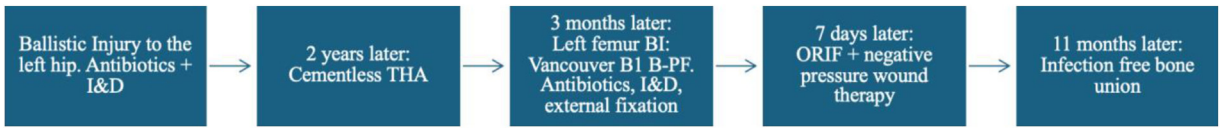

Figure 7. First case: timeline of events and management until bone union.

exacerbating injuries. This practice increases the risk of infection and complicates medical treatment, leading to more severe outcomes for gunshot victims. This gives us reasons to apply the initial recommendation of using associated antibiotics for at least 72 hours in these types of injuries. Zhang et al. [8] reported 69 BI fractures around the hip, with 61% receiving antibiotics. However, it is unclear whether the remaining 39% did not receive antibiotics or if the data were missing from the clinical records. No difference in orthopedic surgery site infection rates, reported to be around 13%, was observed between the 2 groups. Lastly, although infrequent but to take into consideration, Pazarci et al. emphasizes the high risk of infection especially when associated with contamination of the hip joint through intestinal content [9] and even recommends these patients to undergo antibiotic spacer prior to definitive THA. The recommended antibiotic therapy is 1st generation cephalosporin, gentamicin, and penicillin in given cases [10].

Firearm injuries may disrupt bone union through mechanisms such as soft tissue damage, bone devitalization, focal necrosis, or contamination, resulting in nonunion rates comparable to open fractures of nonballistic origin [6]. When considering the possibility of endosteal involvement in a cemented arthroplasty coupled with stress related to the stem tip and stress shielding, the risk of osteosynthesis failure becomes a critical concern [11,12].

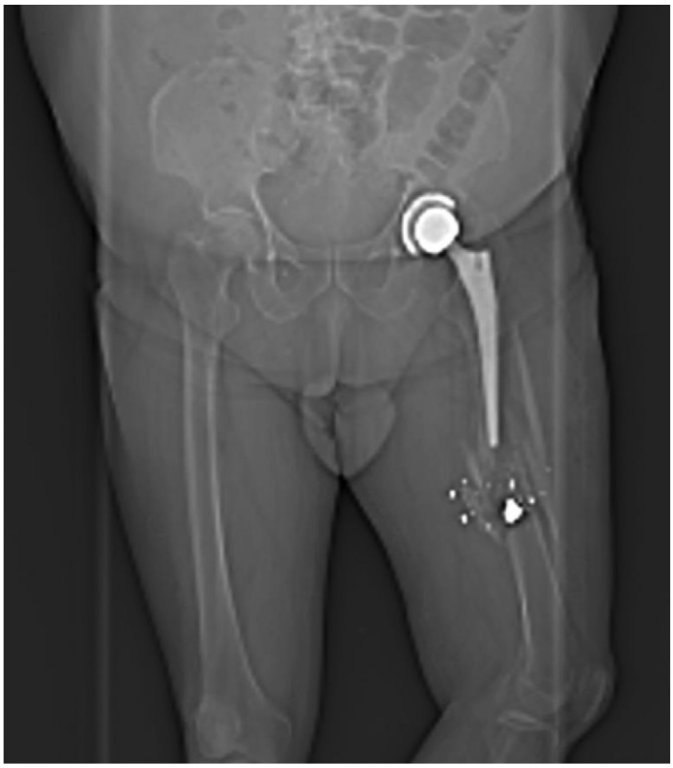

Figure 8. Second case: CT scan scout showing bullet fragments around tip of femoral stem and femoral comminution. CT, computed tomography.

Considering the high incidence of firearm related violence, an almost 10% involvement of the hip and pelvis region would logically and easily explain the possibility of a B-PF [13]. These injuries often present with characteristic comminution and potential implant failure. This is why we recommend cortical strut allografts as support for reduction, to cover and bypass bone defects and increase the stability of the construct [14-17]. Although other authors do not routinely recommend them due to their potential for extensive soft tissue damage, longer surgical time, and consequent potential risk of infection [18], we consider them valuable to maintain the reduction and promote stability over the defects until union is achieved. The use of dual plating has also been described with anteriorly based plates to support lateral locking plates. In their study, Kubik et al [19] reported 31 Vancouver type B1 or C fractures treated with dual plating (second plate mostly anterior). They followed up on 26 and obtained union for 24 of these, with only 2 patients requiring reoperation to obtain union. They reported no cases of deep infection. Current evidence comparing both treatments is lacking. In terms of proximal fixation regarding axial stiffness, there is biomechanical evidence that shows that bicortical locking screws are superior to cerclage wires and monocortical screws [20]. Furthermore, other studies have documented successful outcomes with the use of reversed condylar locking plates for PF [21,22].

Both patients received negative pressure wound therapy. We consider incisional negative pressure wound therapy crucial in B-PF, as it has demonstrated efficacy in revision arthroplasty to reduce infection rates and reoperation [23,24].

Discussion has risen over the last years looking for strategies to reduce periprosthetic joint infections. One of these is extended antibiotic therapy for high-risk patients. Studies have showed that extended oral antibiotics decrease periprosthetic hip joint infection at 3 and 12 months follow-up to 0.89% vs 2.64% in those who did not receive antibiotic [25,26]. We considered our patients to be high risk and therefore treated them with extended oral antibiotics.

Delayed bone union occurred at 11 months in our first case, which is consistent with findings reported by Kim et al [16]. The prolonged time to union underscores the importance of balancing biological healing with stability. Cases with compromised biological integrity may necessitate prolonged time for union, emphasizing the significance of additional stability to alleviate implant load and ensure successful union.

The level of evidence is inherently limited to the type of article. We recognize the limitation in proposing a treatment for patients with a B-PF only having 2 case reports. It is essential to achieve longer follow-ups and more articles regarding this topic to be published, as this can lead to a consensus regarding adequate management for this kind of injury. However, given that to date there are no reports on this subject and our positive outcomes so far, we consider this treatment to be a very reasonable evidence-based approach.

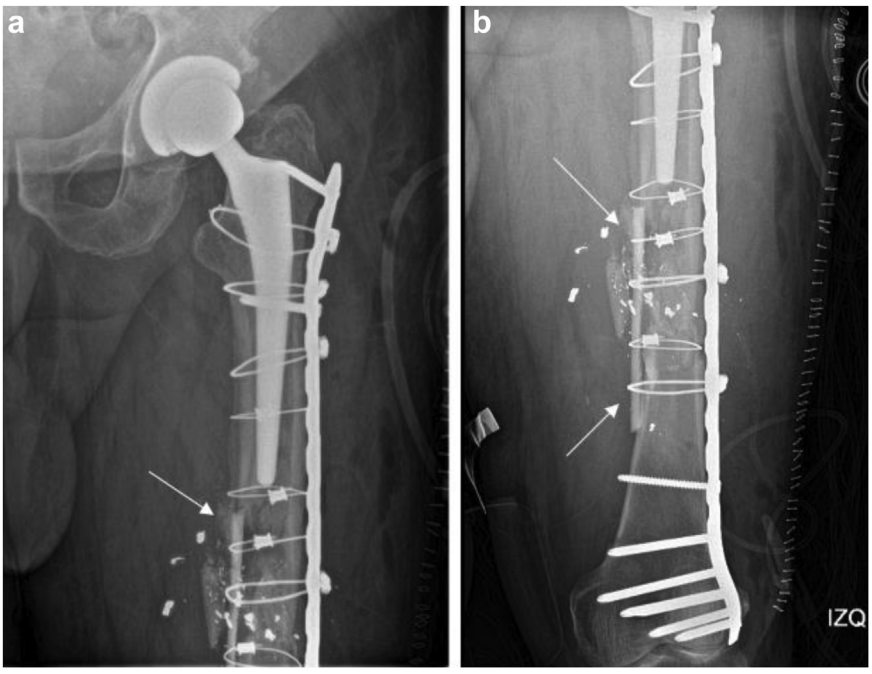

Figure 9. Postoperative anteroposterior (a) proximal and (b) distal left femur radiographs. Cortical alignment can be seen medially (white arrows) fixed with cables.

Summary

Given the complexity of these injuries, we initially defined the treatment as successful if the patients achieved infection-free bone union. Accordingly, we report the outcomes of 2 B-PF cases. One patient was successfully treated, while the other did not have sufficient follow-up time to achieve bone union but remained free of infection at the latest follow-up. We propose using combined antibiotic therapy initially, along with irrigation and debridement, early open reduction internal fixation with cerclage wires and cables, and long locking plates with strut allografts for enhanced stability if necessary. Negative pressure wound therapy after closure and extended oral antibiotics upon discharge are also recommended.

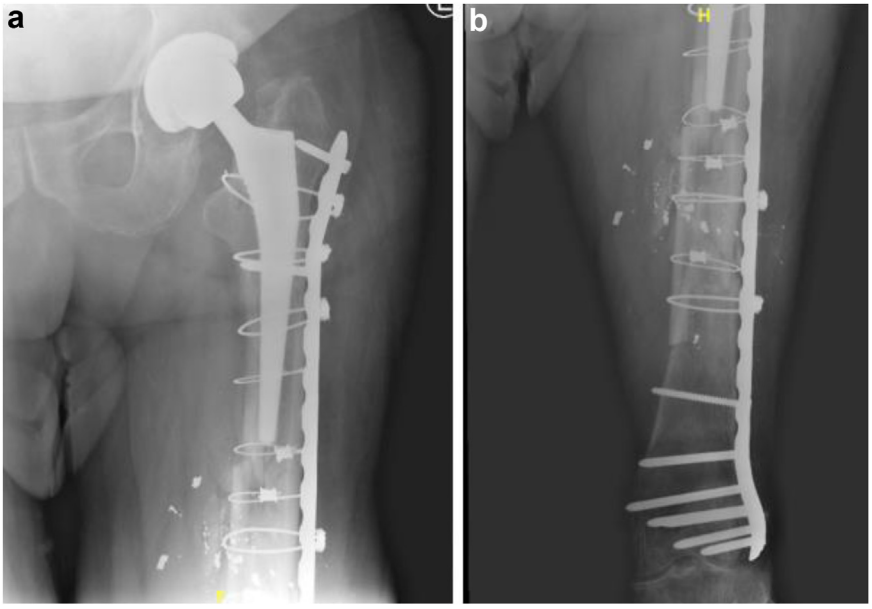

Figure 10. Postoperative anteroposterior (a) proximal and (b) distal left femur radiographs at 3 months. No signs of implant failure at that time.

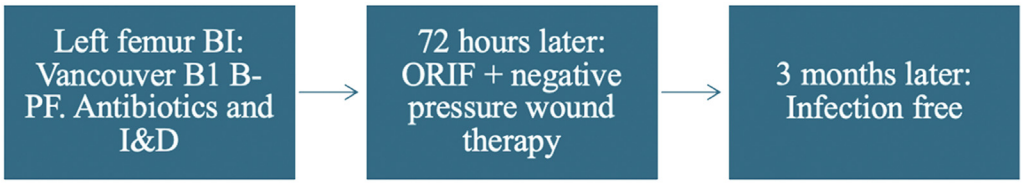

Figure 11. Second case: timeline of events and management until last follow-up.

Conflicts of interest

J. Valenzuela is a Speaker for ZimmerBiomet and DePuy; M. Carmona Paid consultant for Johnson. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101547.

Informed patient consent

Written informed consent was obtained for case report publication.

CRediT authorship contribution statement

Felipe Sandoval: Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization. **Joaquin Valenzuela:** Writing – review & editing, Writing – original draft, Supervision, Methodology. **Maximiliano Carmona:** Writing – review & editing, Writing – original draft, Methodology. **Bénjamin Guiloff:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Martin Salgado:** Writing – review & editing, Writing – original draft.

References

[1] AJRR Steering Committee. AAOS American joint replacement registry 2023 annual report. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2023.
[2] NJR Editorial Committee and contributors. National joint registry / 20th annual report. www.njrcentre.org.uk; 2023. [Accessed 1 March 2024].
[3] Laubscher M, Ferreira N, Birkholtz FF, Graham SM, Maqungo S, Held M. Civilian gunshot injuries in orthopaedics: a narrative review of ballistics, current concepts, and the South African experience. Eur J Orthop Surg Traumatol 2021;31:923–30.
[4] Maqungo S, Kauta N, Held M, Mazibuko T, Keel MJ, Laubscher M, et al. Gunshot injuries to the lower extremities: issues, controversies and algorithm of management. Injury 2020;51:1426–31.
[5] Shetty MS, Kumar MA, Ireshanavar SS, Sudhakar D. Ipsilateral hip and femoral shaft fractures treated with intramedullary nails. Int Orthop 2007;31:77–81.
[6] Metcalf KB, Smith EJ, Wetzel RJ, Sontich JK, Ochenjele G. Comparison of clinical outcomes after intramedullary fixation of tibia fractures caused by blunt trauma and civilian gunshot wounds: a retrospective review. J Orthop Trauma 2020;34:E208–13.
[7] Miclau T, Farjo LA. The antibiotic treatment of gunshot wounds. Injury 1997;28:SC1–5.
[8] Zhang Y, Breydan W, D'Amore P, Hightower C, Stang T, Israel H, et al. Gunshot wounds to the hip: doomed to failure? J. Surg Orthop Adv 2020;29:135–40.
[9] Pazarci O, Kilinc S, Camurcu Y, Bulut O. Total hip arthroplasty after hip joint gunshot injury. J Orthop Surg 2019;27:1–6.
[10] Garner MR, Sethuraman SA, Schade MA, Boateng H. Antibiotic prophylaxis in open fractures: evidence, evolving issues, and recommendations. J Am Acad Orthop Surg 2020;28:309–15.
[11] Xi LC, Li HY, Zhang M, Huang SC. Effects of bone cement filling in rabbit proximal femoral medullary cavity on distal femoral blood flow and metabolism. J Int Med Res 2018;46:5237–44.
[12] Cassar-Gheiti AJ, McColgan R, Kelly M, Cassar-Gheiti TM, Kenny P, Murphy CG. Current concepts and outcomes in cemented femoral stem design and cementation techniques: the argument for a new classification system. EFORT Open Rev 2020;5:241–52.
[13] Antoni A, Maqungo S. Current concepts review: management of civilian transpelvic gunshot fractures. Injury 2023;54:1–6.
[14] Wilson D, Frei H, Masri BA, Oxland TR, Duncan CP. A biomechanical study comparing cortical onlay allograft struts and plates in the treatment of periprosthetic femoral fractures. Clin BioMech 2005;20:70–6.
[15] Matar HE, Selvaratnam V, Jain M, Board TN, Shah N. Cortical strut allografts in salvage revision arthroplasty: surgical technique and clinical outcomes. J Clin Orthop Trauma 2021;17:37–43.
[16] Kim YH, Mansukhani SA, Kim JS, Park JW. Use of locking plate and strut onlay allografts for periprosthetic fracture around well-fixed femoral components. J Arthroplasty 2017;32:166–70.
[17] Masri BA, Meek RMD, Duncan CP. Periprosthetic fractures evaluation and treatment. Clin Orthop 2004;420:80–95.
[18] Moore RE, Baldwin K, Austin MS, Mehta S. A systematic review of open reduction and internal fixation of periprosthetic femur fractures with or without allograft strut, cerclage, and locked plates. J Arthroplasty 2014;29:872–6.
[19] Kubik JF, Bornes TD, Gausden EB, Klinger CE, Wellman DS, Helfet DL. Surgical outcomes of dual-plate fixation for periprosthetic femur fractures around a stable hip arthroplasty stem. Arch Orthop Trauma Surg 2022;142:3605–11.
[20] Griffiths JT, Taheri A, Day RE, Yates PJ. Better axial stiffness of a bicortical screw construct compared to a cable construct for comminuted vancouver B1 proximal femoral fractures. J Arthroplasty 2015;30:2333–7.
[21] Ochi H, Baba T, Tanabe H, Ozaki Y, Watari T, Homma Y, et al. Autograft-prosthesis composite use for a Vancouver type B1 periprosthetic femur fracture with pelvic acetabular component migration after bipolar hemiarthroplasty: a case report. Trauma Case Rep 2019;22:1–5.
[22] Baba T, Homma Y, Morohashi I, Maruyama Y, Shitoto K, Kaneko K. Is internal fixation using a reversed condylar locking plate useful for treating Vancouver type B1 periprosthetic femoral fractures? Eur Orthop Traumatol 2015;6:137–43.
[23] Newman JM, Siqueira MBP, Klika AK, Molloy RM, Barsoum WK, Higuera CA. Use of closed incisional negative pressure wound therapy after revision total hip and knee arthroplasty in patients at high risk for infection: a prospective, randomized clinical trial. J Arthroplasty 2019;34:554–559.e1.
[24] Ailaney N, Johns WL, Golladay GJ, Strong B, Kalore NV. Closed incision negative pressure wound therapy for elective hip and knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. J Arthroplasty 2021;36:2402–11.
[25] Inabathula A, Dilley JE, Ziemba-Davis M, Warth LC, Azzam KA, Ireland PH, et al. Extended oral antibiotic prophylaxis in high-risk patients substantially reduces primary total hip and knee arthroplasty 90-day infection rate. J Bone Joint Surg Am 2018;100:2103–9.
[26] Kheir MM, Dilley JE, Ziemba-Davis M, Meneghini RM. The AAHKS clinical research award: extended oral antibiotics prevent periprosthetic joint infection in high-risk cases: 3855 patients with 1-year follow-up. J Arthroplasty 2021;36:S18–25.