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Case Series

From fracture to function: surgical management of trifocal femur fractures: a case series

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ABSTRACT

Trifocal femur fractures, characterized by fractures occurring at three distinct levels of the femur, are exceptionally rare injuries that usually result from high-energy trauma. Their management is challenging due to limited published evidence, complex fracture patterns, and the technical difficulty of achieving stable fixation across multiple segments. We present a case series of four patients with ipsilateral multilevel femur fractures, including trifocal injury patterns. Case 1 sustained a subtrochanteric fracture associated with a segmental shaft fracture; case 2 had an intertrochanteric fracture with a segmental shaft fracture; case 3 presented with intertrochanteric, shaft, and distal intra-articular femur fractures; and case 4 sustained fractures of the femoral neck, shaft, and distal femur. All patients underwent surgical management using individualized fixation strategies, including long proximal femoral nailing, cancellous screw fixation, bone grafting, and distal femoral plating as required. Radiological union was achieved in all fracture components except for incomplete union of the distal femur in one patient at two-year follow-up. Functional outcomes were satisfactory in all patients, with restoration of limb alignment, implant stability, and ambulatory function. Early recognition, meticulous preoperative planning, and stable fixation using appropriate load-sharing constructs are essential for achieving favorable outcomes in these complex injuries.

Keywords: Trifocal femur fracture, High-energy trauma, Intramedullary nailing, Fracture fixation, Case series

INTRODUCTION

Isolated femoral shaft fractures are relatively common injuries, with an estimated annual incidence of approximately 10 per 100,000 person-years. Multifocal femur fractures are less frequently encountered, with an associated proximal femoral fracture reported in up to 5% of diaphyseal fractures and an additional distal femoral fracture occurring in approximately 3-4% of cases.[1] Rarely, fractures of the proximal femur, femoral shaft, and distal femur occur simultaneously, constituting a trifocal femur fracture pattern.

Trifocal femur fractures were first described by Kách in 1993.[2] These injuries typically result from high-energy mechanisms such as high-speed road traffic collisions, falls from height, and pedestrian-vehicle accidents and are more commonly seen in younger patients.[1,3,4]

The presumed mechanism of injury involves the hip being flexed and abducted, allowing the femoral head to remain well positioned within the acetabulum, while a longitudinal force transmitted from the knee propagates stress along the femoral shaft, resulting in fractures at multiple levels.[3]

The treatment of ipsilateral multilevel femur fractures is challenging due to the complexity of the injury pattern.[7] An implant suitable for fixation of 1 fracture component may not be optimal for another. Various fixation techniques and implant combinations have been described for these fractures however, there is no conclusive

evidence supporting the superiority of any specific implant.[1,3,5]

Because of the rarity of these injuries and the heterogeneity of fracture configurations, there is no consensus regarding optimal treatment strategy or sequence of fracture fixation. Consequently, most authors emphasize an individualized approach to management based on fracture morphology, patient factors and available surgical expertise.[1,3-7]

CASE SERIES

Four patients with trifocal femur fractures were treated surgically at our tertiary trauma centre between 2020 and 2023. All injuries resulted from high-energy trauma, including three road traffic accidents and one fall from height. Preoperative assessment included standard anteroposterior and lateral radiographs of the entire femur, with computed tomography performed when intra-articular involvement was suspected. Fractures were classified according to the AO/OTA classification system. Postoperatively, early mobilisation was encouraged, with progression to full weight-bearing following radiographic evidence of union. Clinical and radiological follow-up was carried out at 6 weeks, 3, 6, 12 and 24 months.

Case 1

A 22-year-old male sustained a high-energy road traffic accident and presented with pain and deformity of the left thigh. Radiographs demonstrated a subtrochanteric femur fracture (AO 32-A2) associated with a segmental shaft fracture (AO 32-C3) (Figure 1). The patient underwent closed reduction and internal fixation using a long proximal femoral nail. Progressive radiological union was noted at 12 months (Figure 2), with complete union and good functional recovery at the 2-year follow-up (Figure 3).

Case 2

A 35-year-old male sustained injuries following a fall from height. Imaging revealed an intertrochanteric femur fracture (AO 31-A1.2) with an associated segmental shaft fracture (AO 32-C2) (Figure 4). Surgical management involved fixation with a long proximal femoral nail. At the 2-year follow-up, radiographs demonstrated complete union of both fracture components with maintained alignment and implant stability (Figure 5), and the patient had regained independent ambulation.

Case 3

A 55-year-old female pedestrian was struck by a motor vehicle and sustained an intertrochanteric femur fracture (AO 31-A1.2), a shaft fracture (AO 32-A3), and a distal femur fracture with intra-articular extension (AO 33-C3.1) (Figure 6). The fractures were managed with a long proximal femoral nail supplemented by cancellous screw fixation and a medial tibial buttress plate. Radiographs at 2-year follow-up showed complete union at all three fracture levels with satisfactory limb alignment and functional recovery (Figure 7).

Case 4

A 40-year-old male sustained a high-energy road traffic accident resulting in a femoral neck fracture (AO 31-B3), shaft fracture (AO 32-A3), and a comminuted distal femur fracture (AO 33-C3.3) (Figure 8). Surgical fixation consisted of cancellous screws for the femoral neck, bone grafting, and distal femoral plating (Figure 9). At the 2-year follow-up, radiological union was achieved at the femoral neck and shaft; however, the distal femur fracture showed incomplete union (Figure 10). Despite this, the patient achieved independent ambulation with acceptable hip and knee function.

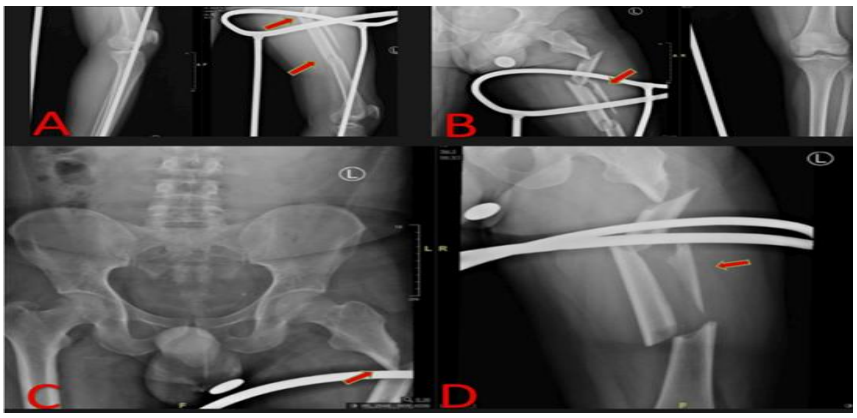

Figure 1 (A-D): Pre-op radiographs of left femur showing a subtrochanteric femur fracture (AO-32A2) along with a segmental shaft of femur fracture (AO-32C3). (A) Lateral radiograph of left segmental shaft femur fracture. (B) Anteroposterior radiograph of left subtrochanteric and segmental shaft of femur fracture. (C) Anteroposterior radiograph of pelvis with bilateral hip showing left subtrochanteric femur fracture. (D) Lateral radiograph of left thigh showing left subtrochanteric femur fracture and a segmental shaft femur fracture.

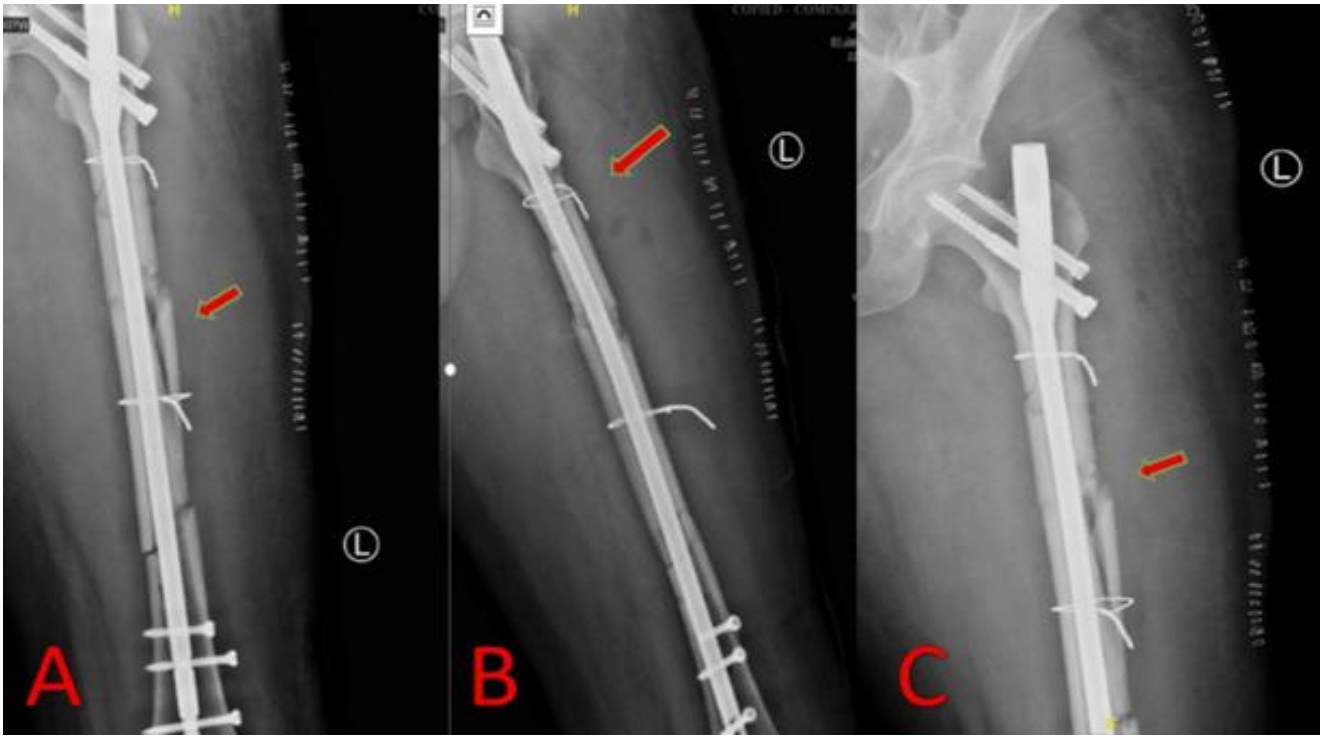

Figure 2 (A-C): Anteroposterior and lateral radiographs of the left femur at 12-month follow-up in case 1 showing a well-aligned and uniting subtrochanteric and segmental shaft fracture following intramedullary nailing. (A) Anteroposterior radiograph showing uniting left segmental shaft femur fracture. (B) Lateral radiograph showing uniting left subtrochanteric and segmental shaft femur fracture. (C) Anteroposterior radiograph showing uniting left subtrochanteric and segmental shaft femur fracture.

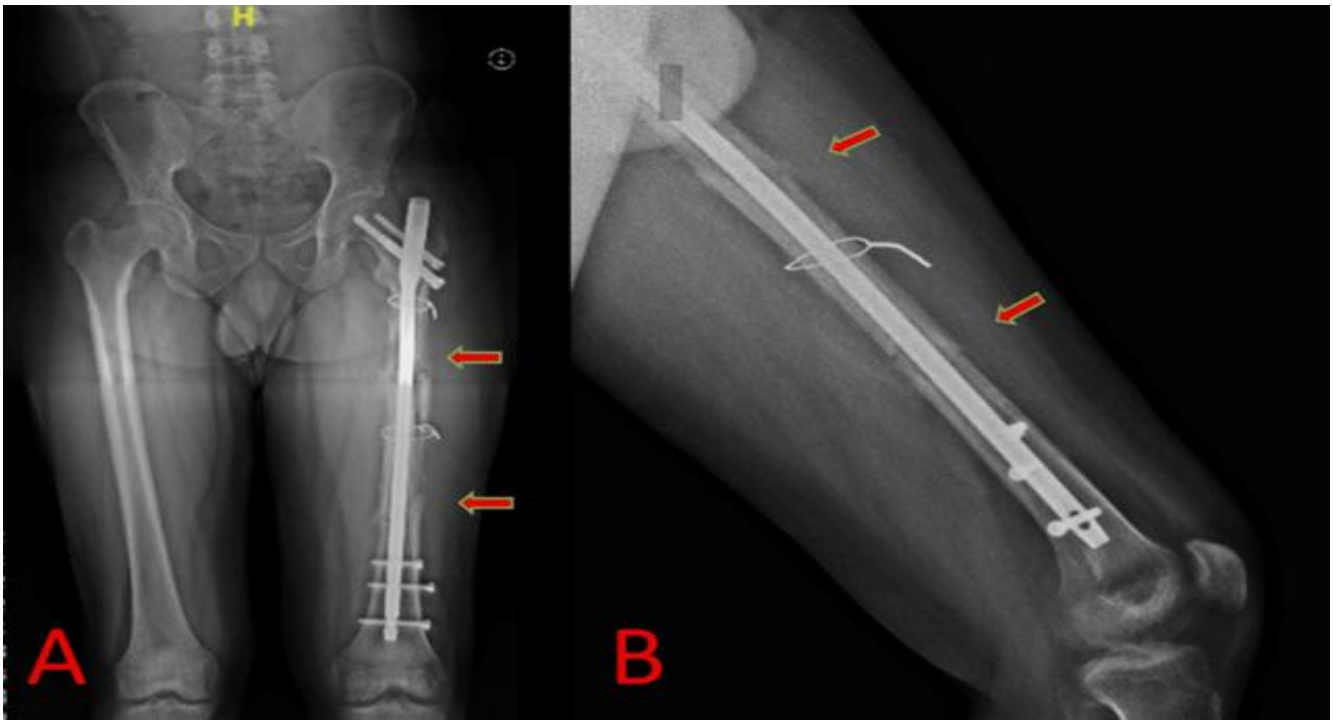

Figure 3 (A and B): Anteroposterior and lateral radiographs of the left femur at two-year follow-up in case 1 showing complete union of the subtrochanteric and segmental shaft fractures with maintained alignment and implant integrity. (A) Anteroposterior radiograph of left femur showing complete union of the subtrochanteric and segmental shaft fractures. (B) Lateral radiograph of the left femur showing complete union of the subtrochanteric and segmental shaft fractures.

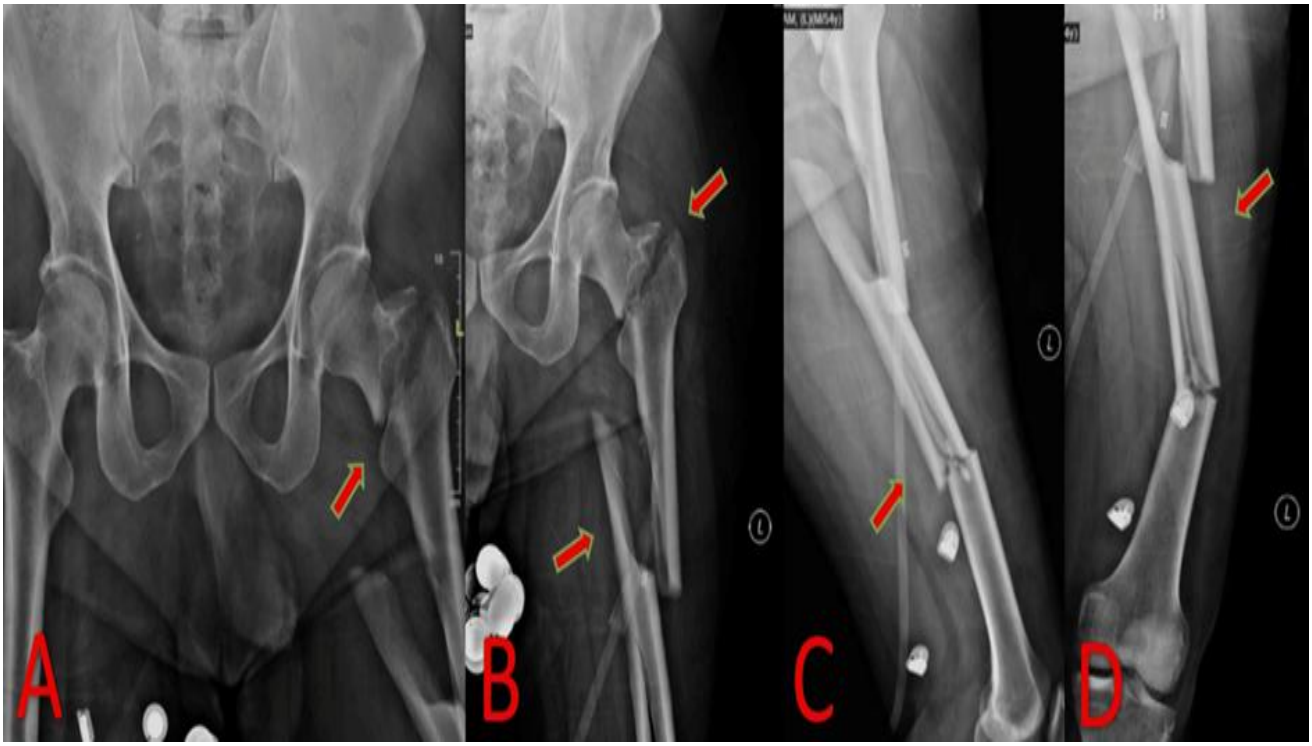

Figure 4 (A-D): Pre-operative radiographs of the left femur in case 2 showing an intertrochanteric femur fracture (AO-31A1.2) along with a segmental shaft of femur fracture (AO-32C2). (A) Anteroposterior view of pelvis with bilateral hip showing intertrochanteric fracture of left femur. (B) Anteroposterior view of left femur showing intertrochanteric fracture of left femur and proximal shaft of femur fracture. (C) Lateral view of left femur showing intertrochanteric fracture of left femur and segmental shaft of femur fracture. (D) Anteroposterior view of left femur showing segmental shaft of femur fracture.

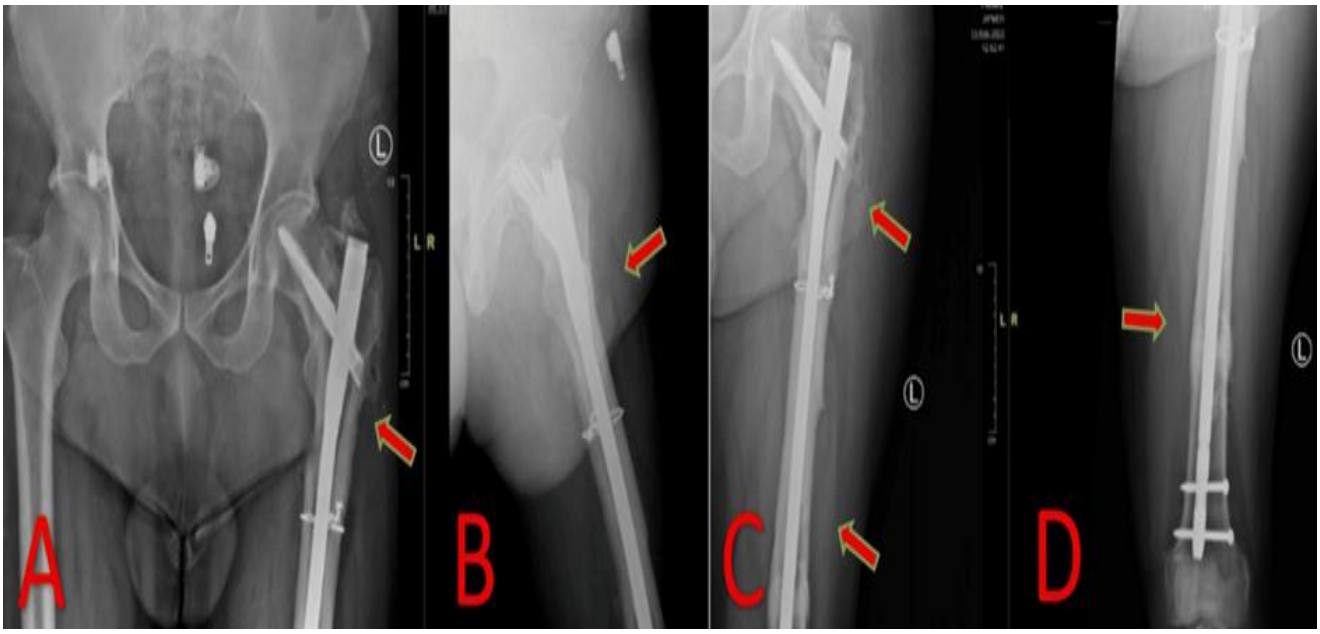

Figure 5: Anteroposterior and lateral radiographs of the left femur at two-year follow-up in case 2 showing complete union of the intertrochanteric and segmental shaft of femur fractures with maintained alignment and implant integrity. (A) Anteroposterior radiograph of pelvis with bilateral hip showing united left intertrochanteric femur fracture. (B) Lateral radiograph of left proximal femur showing united left intertrochanteric femur fracture. (C) Anteroposterior radiograph of left proximal thigh showing united left segmental shaft of femur. (D) Anteroposterior radiograph of left distal thigh showing united left segmental shaft of femur.

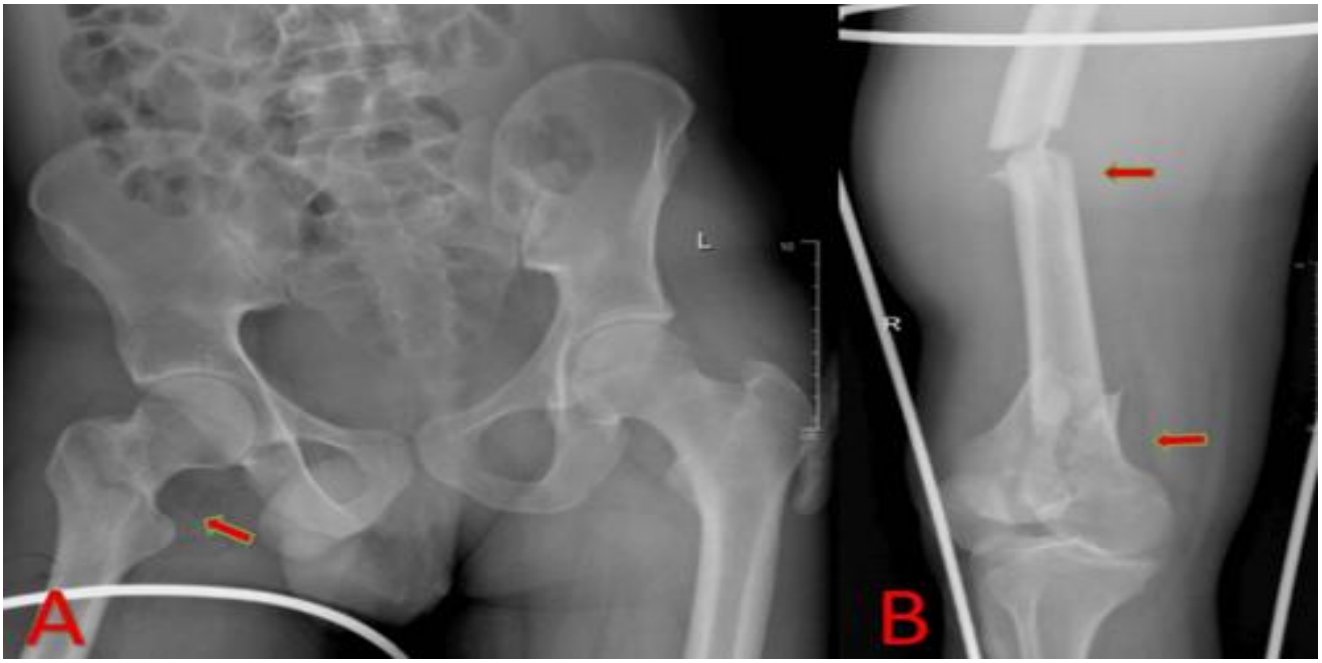

Figure 6 (A and B): Pre-operative radiographs of the right femur in case 3 showing an intertrochanteric femur fracture (AO-31A1.2) along with a shaft of femur fracture (AO-32A3) and a distal femur fracture with intra-articular extension (AO-33C3.1). (A) Anteroposterior radiograph of pelvis with bilateral hip showing a right intertrochanteric femur fracture. (B) Anteroposterior radiograph of right thigh with knee showing a right shaft of femur fracture with distal femur intra-articular fracture.

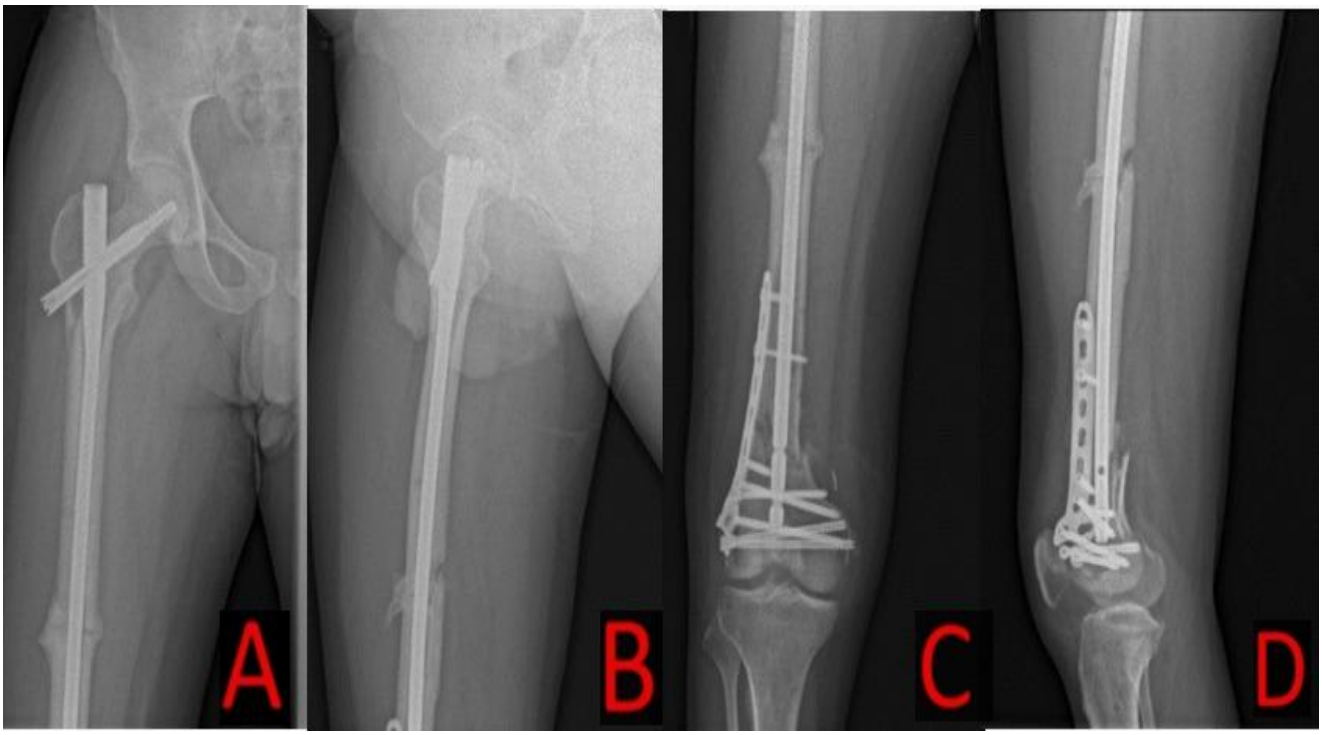

Figure 7 (A-D): Anteroposterior and lateral radiographs of the right femur at two-year follow-up in case 3 showing complete union of the segmental shaft and intra-articular distal femur fractures with maintained alignment and intact implants. (A) Anteroposterior radiograph of right hip showing united right intertrochanteric and shaft of femur fracture. (B) Lateral radiograph of right hip showing united right intertrochanteric and shaft of femur fracture. (C) Anteroposterior radiograph of right thigh showing united right shaft of femur fracture and distal femur fractures. (D) Lateral radiograph of right thigh showing united right shaft of femur fracture and distal femur fractures.

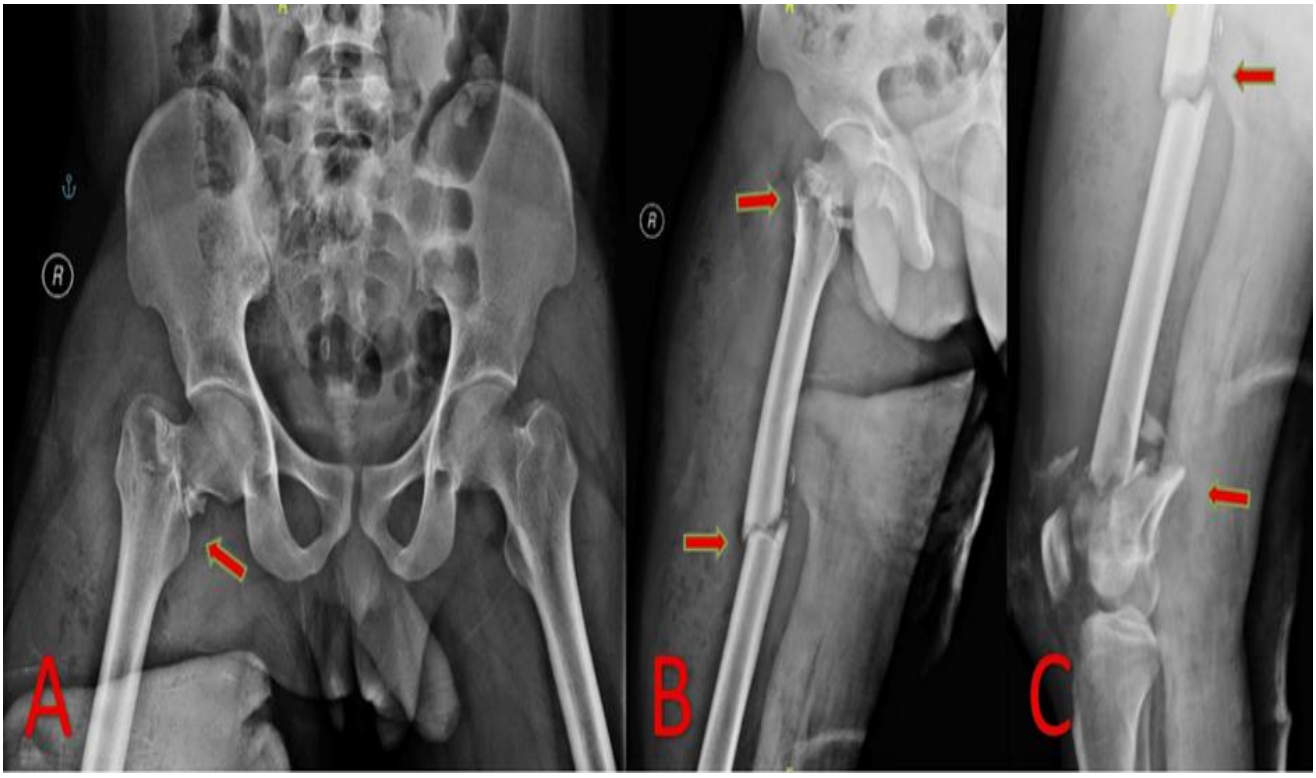

Figure 8 (A-C): Pre-operative radiographs of the right femur in case 4 showing a neck of femur fracture (AO-31B3), femur shaft fracture (AO-32A3), and a distal femur comminuted fracture (AO-33C3.3). (A) Anteroposterior radiograph of pelvis with bilateral hip showing right neck of femur fracture. (B) Lateral view of right proximal thigh showing right neck of femur and shaft of femur fracture. (C) Lateral view of right distal thigh showing right neck of femur and shaft of femur fracture.

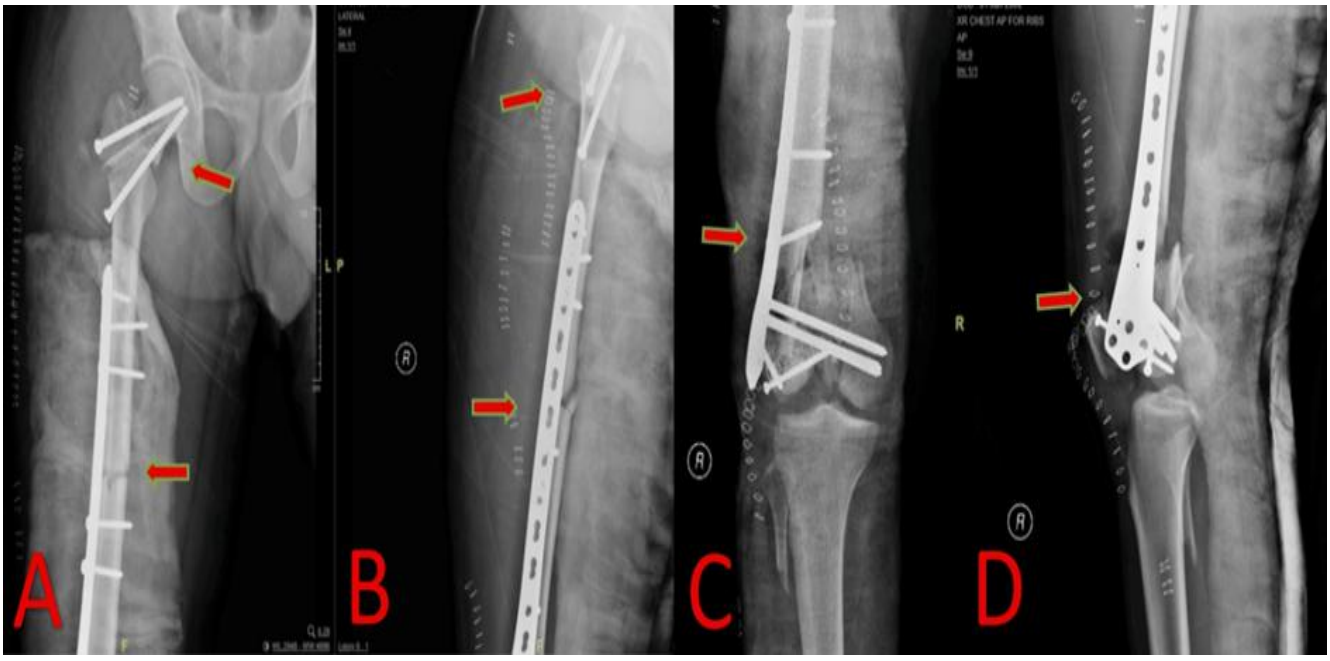

Figure 9 (A-D): Post-operative anteroposterior and lateral radiographs of the right femur in case 4 showing fixation of the femur fractures using cancellous screws, bone grafting, and distal femoral plate. (A) Anteroposterior radiograph of right proximal thigh showing fixation of right neck of femur and shaft of femur fractures. (B) Lateral radiograph of right proximal thigh showing fixation of right neck of femur and shaft of femur fractures. (C) Anteroposterior radiograph of right distal thigh showing fixation of right distal femur fracture. (D) Lateral radiograph of right distal thigh showing fixation of right distal femur fracture.

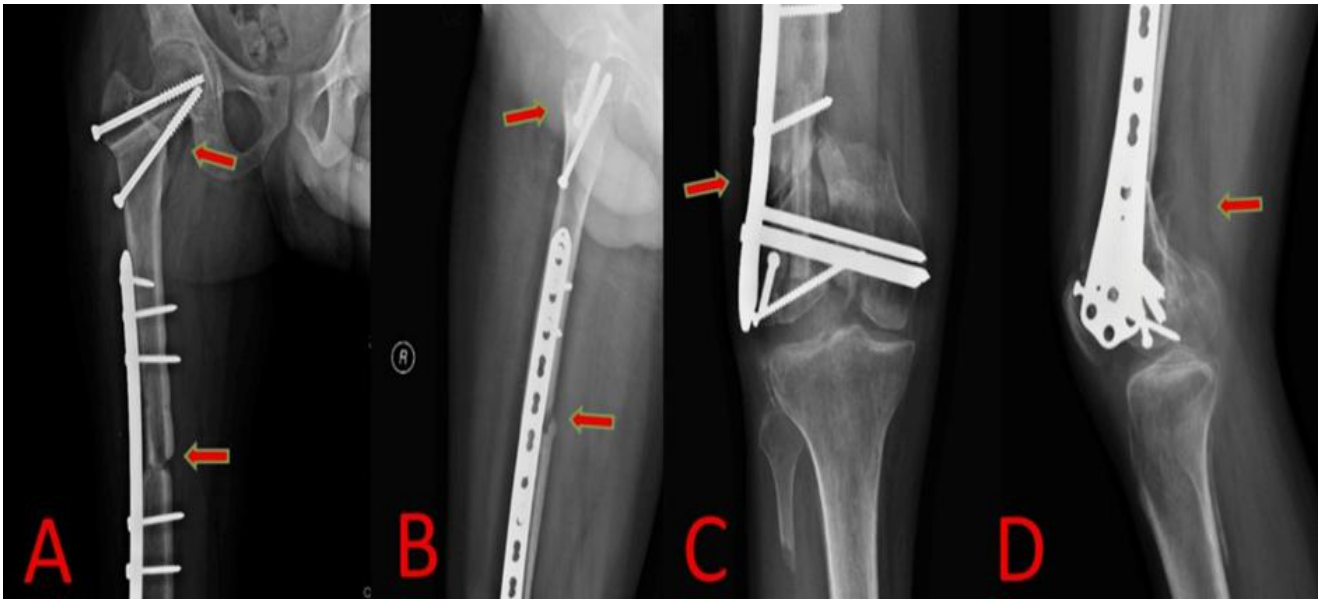

Figure 10 (A-D): Anteroposterior and lateral radiographs of the right femur at two-year follow-up in case 4 showing incomplete union of the distal femur fracture. (A) Anteroposterior radiograph of right proximal femur showing union of right neck and shaft of femur fracture. (B) Lateral radiograph of right proximal femur showing union of right neck and shaft of femur fracture. (C) Anteroposterior radiograph of right distal femur showing incomplete union of the right distal femur fracture. (D) Lateral radiograph of right distal femur showing incomplete union of the right distal femur fracture.

Overall, all patients achieved early mobilisation with restoration of limb alignment and implant integrity. Radiological union was achieved in all fracture components except for incomplete distal femoral union in 1 patient. No complications such as implant failure, infection/malalignment were observed during follow-up.

DISCUSSION

Trifocal femur fractures are rare injuries, with only a limited number of cases reported in the literature. The first description was provided by Käch in 1993, who reported a basicervical femoral neck fracture associated with a segmental shaft fracture and a distal femur fracture.[2] In that case, fixation was achieved using lag screws proximally, a 95° blade plate for the distal femur, and a locking nail for the shaft component.

Subsequently, Bartoníček et al described a case involving a stable pertrochanteric fracture, a diaphyseal fracture, and a T-shaped distal femur fracture, along with an associated ipsilateral patellar fracture.[10] The injury was managed using a reconstruction nail and a 95° blade plate. Barei et al. later reported a series of seven patients aged between 19 and 63 years with non-contiguous fractures involving the proximal femur, shaft, and distal femur.[4] In their series, the proximal fracture was intracapsular in most cases, while one patient had a basicervical fracture. A variety of fixation methods were used, including cannulated screws, dynamic hip screws, and reconstruction nails. All distal fractures were unicondylar, and the diaphyseal component was treated using either intramedullary nailing or plating. Although fracture union was achieved in all cases, malunion of the femoral neck occurred in one patient.

The management of trifocal femur fractures is particularly challenging, as fixation of one fracture segment may interfere with optimal stabilization of the remaining components. For this reason, most authors advocate an individualized approach rather than a uniform treatment protocol.[1-5] The choice of implant is usually dictated by the fracture morphology at the proximal and distal ends of the femur. Femoral neck fractures may be treated with cancellous screws, whereas pertrochanteric and subtrochanteric fractures are commonly managed with a dynamic hip screw or an intramedullary hip nail. The femoral shaft component is most often stabilized with an intramedullary nail, although plating may be required when addressing an associated distal femur fracture.

Various techniques have been described for fixation of the distal femur, including lag screws, 95° blade plates, reconstruction nails, and anatomical locking plates.[1-7] Despite these options, there is no clear consensus regarding the optimal sequence of fixation. Barei et al recommended addressing the proximal fracture first, followed by fixation of the distal and shaft components.[4] In contrast, Lambiris et al suggested stabilizing the distal fracture initially before treating the remaining fractures.[11] In practice, the sequence of fixation is influenced by fracture configuration, patient condition, and the surgeon's experience.

Several authors have reported that satisfactory outcomes can often be achieved using only two implants, with the

shaft fracture being stabilized in combination with either the proximal or distal fracture.[4,10] It has also been suggested that because injury energy is distributed across multiple fracture sites, vascular compromise at individual fracture levels may be less severe. As a result, union is generally achieved unless complicated by factors such as open injuries or significant comorbidities.

Based on our experience, the heterogeneity of fracture patterns in trifocal femur fractures necessitates a flexible and individualized treatment strategy. We propose a descriptive classification based on the anatomical involvement of fracture components: pure diaphyseal trifocal fractures, trifocal fractures involving the proximal femur, those involving the distal femur, and fractures involving both proximal and distal segments. While this classification may assist with preoperative planning and implant selection, further studies are required to assess its clinical usefulness.

CONCLUSION

Trifocal femur fractures are complex, high-energy injuries with limited published evidence to guide management. Early diagnosis, careful surgical planning, and stable fixation are critical for optimizing outcomes. Reporting such cases is vital to build a stronger evidence base and to refine future treatment strategies.

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