



# A Case of Femoral Neck Fracture in a 19-year-old with Subsequent Non-Union and Avascular Necrosis

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## Abstract

Low energy intra capsular neck of femur fractures in young adults represents a rare clinical entity. The prompt reduction and surgical fixation of these fractures, preserving the hip joint and allowing the uncomplicated union of this anatomic area remains challenging. An example of such a case on a young long-distance runner is presented, where a combination of non-union of the fracture site, as well as a grade IIB avascular necrosis area followed the initial closed reduction and internal fixation. These complications were successfully managed with a single revision surgery where the full array of the diamond concept was applied. The patient progressed to an uneventful healing of the non union of the femoral neck, reverse of avascular necrosis, preservation of the hip joint anatomy and return to the full spectrum of activities including sports.

## Introduction

Low energy fractures of the femoral neck represent a relatively common type of fracture, especially in the elderly population, and are associated with low bone density and high risk of simple falls. The routine treatment of choice is a hip arthroplasty within 48hrs, to facilitate the early unrestricted mobilisation of the patient [1,2]. The same fractures for younger adults are quite infrequent, and pose a significant surgical challenge, as in order to preserve the native hip, accurate reduction of the fracture and stable internal fixation, is offered in an emergency manner to minimize secondary complications attributed to the precarious blood supply to the femoral head [3-6]. We present a case that despite the optimal primary treatment it developed the full sequel of secondary complications and following multifaceted revision surgery achieved eventually successful healing and optimal hip function.

## Case Presentation

A nineteen-year-old female patient was admitted to the Trauma and Orthopaedic ward following a simple fall from standing height at home. X-rays on admission revealed a displaced left neck of femur fracture (Figure 1a and b). The patient had complained of left hip pain for 6 weeks prior to the injury and was a keen amateur long-distance runner, suggesting that this fracture was the completion of a pre-existing stress fracture. She was otherwise completely fit and well. Three hours after her admission, the patient was taken to theatre and three parallel 6.5 mm cannulated screws (single inferior, two superior parallel screws) were used to fix her femoral neck following a successful closed reduction (Figure 2) [7]. Post-operatively serum blood tests were undertaken to investigate any underlying metabolic cause for the injury, which revealed deficiency

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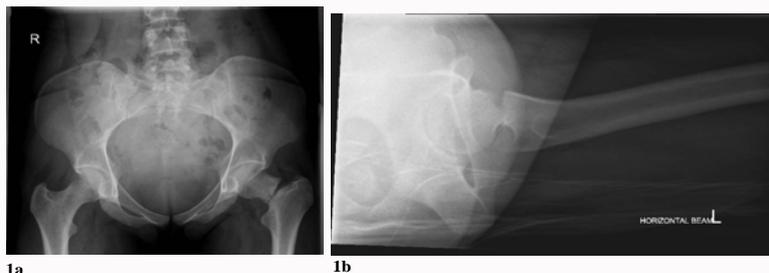
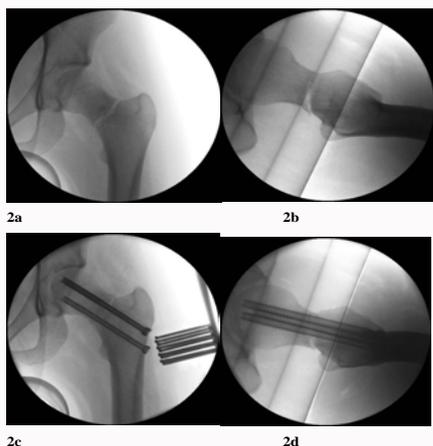


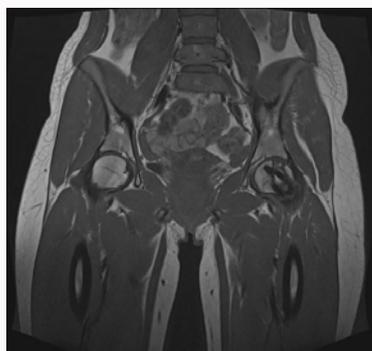
Figure 1: AP and lateral radiographs of the pelvis and left hip respectively. These were both taken on admission.



**Figure 2:** Intraoperative radiographs of the achieved closed reduction, and subsequent internal fixation with 3 cannulated 6.5mm screws on the day of admission.



**Figure 3:** Coronal reconstruction and Axial CT-images respectively at 6-months post-operatively revealing delayed union.

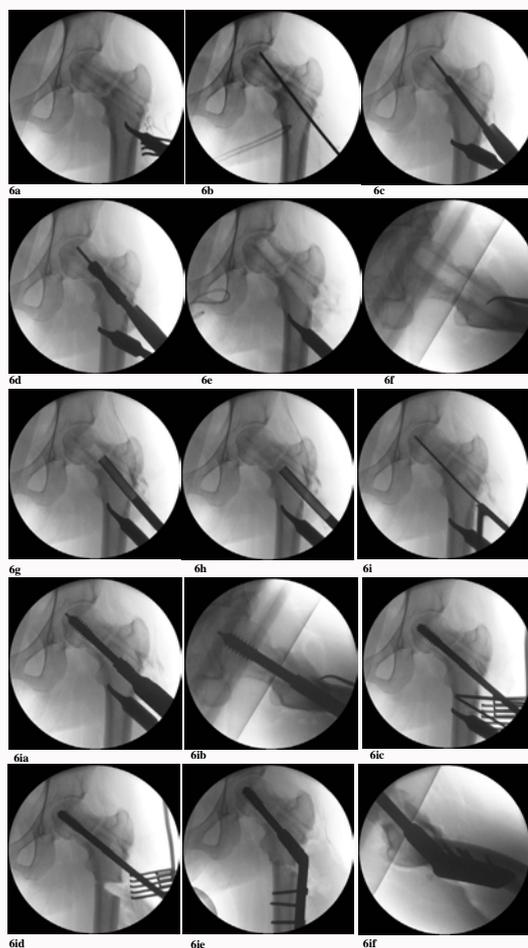


**Figure 4:** Coronal MRI with T1 weighted WARP sequencing at 8-months post-operatively revealing AVN of the femoral head.

in 25-hydroxycholecalciferol (Vitamin-D) levels at 38nmol/L. Other parameters were all within normal limits and the patient was prescribed a Vitamin-D supplement on discharge 3-days post-operatively. The patient was kept non-weight bearing for 6-weeks post-op and given a prophylactic subcutaneous dose of low molecular weight heparin daily during that time. After the initial 6-weeks, weight bearing was gradually increased over the following 6-weeks until she was able to fully-weight bear at 12-weeks post-op. At 6-months the patient had some residual hip pain and a CT-scan revealed no evidence of bony union, (Figure 3a and b). Examination also revealed internal rotation and flexion of the hip limited by pain. Further imaging in the form of an MRI scan revealed no further evidence of bony union, and also a stage IIB [8] avascular necrosis (AVN) of the femoral head,



**Figure 5:** Planning images of the correction extra acritcular closed wedge valgus osteotomy of the proximal femur. The nonunion Pauwels angle was measured (defined by the horizontal beam and the neck nonunion line- found to be 49°). The wedge angle of the osteotomy is determined as the difference between the nonunion Pauwels angle to the desired one (25°-30°). Thus, in this case the wedge angle was around 22° (19° to 24°). Aiming for the osteotomy level not to conflict with the entry point of the DHS lag screw, the planning determined a wedge osteotomy around the level of the lesser trochanter with a lateral cortical width measured to be 12 mm in order to have the 22° of valgus correction.



**Figure 6:** Series of intra-operative radiographs showing: a) removed cannulated screws tracks; b)guide wire insertion targeting the necrotic lesion c) and d)two step reaming and debridement of necrotic lesion, e) and f) decompressed area of the AVN; g) and h) staged insertion of the composite graft (BMP-7 +BMAC) to the tract of decompression of the femoral head and the femoral neck non-union; i, ia) and ib) insertion of the DHS guide wire and the DHS lag screw; ic) creation of valgus osteotomy with two osteotomes, id) removal of a wedge of 12mm width as per preop osteotomy planning (see Figure 5); and ie) and if) final appearance of the closed wedge osteotomy after plating with a long DHS.



**Figure 7:** a) The specialised kit for AVN of EON MEDICA srl that was used for the femoral decompression, as well as the delivery of the composite biologic augmentation with b) BMP-7- Olympus Biotech and c) BMACcells-MarrowStim Biomet, to the nonunion and AVN sites of the proximal femur of this patient.

(Figure 4). The patient underwent further surgery with removal of the cannulated screws, decompression of the area of avascular necrosis using the system of EON MEDICA strand augmentation with BMP-7 (Osigraft<sup>®</sup>, Olympus Biotech) and bone marrow aspirate concentrate (BMAC-MarrowStim<sup>™</sup> Concentration System, Biomet) to the femoral head, following the technique previously described. The specific technique of this procedure is described to a recent publication by Calori et al. [9]. A valgus proximal femoral osteotomy was performed and Dynamic Hip Screw (DHS) insertion with a 135° lag screw angle and 6-hole long plate, (Figures 5-7). The level and width of the closed wedge valgus osteotomy of the proximal femur was determined following standard techniques as described at (Figure 5) [10,11]. The patient had a period of 6-weeks non-weight bearing following this surgery and then progressed to full weight bearing over a 1-month period. Following that she had intermittent follow-up reviews due to changes to her permanent residence. At her 3-year review she was pain free, with restoration of the full spectrum of her activities and a very good level of function, having ran a half-marathon the day before. Her radiological imaging revealed healing of the non union site, restoration of the neck shaft angle and no evidence of further progression of the avascular necrosis of the femoral head (Figure 8).

## Discussion

Stress fractures occur following cyclical loading of bone, where the normal remodelling process is unable to keep pace with the mechanical stresses exerted and therefore crack propagation can occur. Femoral stress fractures account for approximately 7% of all stress fractures, with femoral neck stress fractures rarer still at around 1%, and are most commonly seen in military recruits or long-distance runners, as in our case [12,13]. Typically, patients will report groin or anterior thigh pain while exercising, which progressively worsens. As these patients typically experience general aches and pains associated with their high level of activity, there is often a significant diagnostic delay of several weeks [3,14]. If the initial diagnosis is not recognised, the fracture can progress to completion and subsequent displacement. The presented case may represent such a stress/fatigue fracture in the absence of a significant mechanism of trauma as well as the retrospectively reported dull ache at this patient's groin area.

Displaced femoral neck fractures have a significantly poorer prognosis due to the increased risk of non-union and avascular necrosis (AVN) [6,15,16]. Studies of military recruits with displaced femoral neck fractures treated operatively report that up to 24% may develop AVN, with delayed fixation and post-operative malalignment being associated with an increased rate of AVN [13]. In others studies of athletes and military personnel, between 44% and 54% of patients were not able to return to their previous level of activity within the follow-up period [6,12,13,16].



**Figure 8:** X-ray at 3 years following revision surgery and a day after running a half marathon. There is some heterotopic ossification seen lateral to the plate. This was asymptomatic and was attributed to spillage of the augmentation graft through the cannulation of the DHS lag screw. The femoral neck nonunion was fully healed and the avascular necrosis area at the femoral head demonstrated no further progression. The achieved correction of neck shaft angle was measured as 130° to the unaffected right femur and 131° to the operated left one.

The treatment of AVN depends on the severity of collapse associated with the area of necrosis. More advanced disease with collapse is associated with poorer treatment outcomes and is likely to require reconstructive or arthroplasty surgery. In less advanced disease without collapse, core decompression and supplementary bone grafting and biologic augmentation has been shown to have satisfactory outcomes [16]. The specific technique used in this patient has been previously described by our group [9]. The use of potent osteoinductive agents, such as bone morphogenic proteins (BMPs), has been shown to have a positive effect on bone healing in a large number of studies [17,18]. The biologic augmentation of a healing bone area (fractures, nonunions, bone necrosis, joint areas, bone defects) has been extensively investigated as far as to its essential components and has been expressed conceptually as the “diamond concept” [9,19,20]. It includes the following essential elements namely osteoinductive growth factors, osteoconductive scaffolds, osteogenic cells, local vascular supply, and optimal mechanical stability/stimuli.

## Conclusion

This case demonstrates the potential severity of displaced femoral neck fractures even in young healthy patients, with the attendant high risk of complications such as non-union and AVN leading to poor functional outcome and secondary surgeries. It also highlights the importance of post-operative monitoring in these patients and the positive outcomes that can be achieved if these complications (both the avascular necrosis and the femoral neck nonunion) are treated promptly with composite contemporary techniques optimizing simultaneously the mechanical and biological local environment.

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