Trauma Case Reports 36 (2021) 100555

Contents lists available at ScienceDirect

Trauma Case Reports

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

Case Report

Exchange nailing and medial wall reconstruction following implant failure in a subtrochanteric femoral fracture

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ARTICLE INFO

Keywords:
Femur
Non-union(s)
Subtrochanteric
Nail
Revision

ABSTRACT

Failure of fixation of subtrochanteric fractures has been reported in as high as 20% of cases. Several associations have been suggested to contribute to failed fixation. Discontinuity of the medial wall/column is considered to be one of the most significant risk factors for non-union and subsequent implant failure, especially if this defect is not addressed during the revision surgery. We present a case of failed fixation of a subtrochanteric fracture in an 86-year-old female where revision surgery paid special attention to restoring the medial wall continuity via bone grafting resulting in satisfactory union of the fracture. We advocate the necessity of reconstructing the medial column in similar cases in order to enhance healing and restore the biomechanical support of the subtrochanteric region.

Background

Subtrochanteric femoral fractures are defined as those occurring up to 5 cm below the distal border of the lesser trochanter and constitute up to 30% of all proximal femoral fractures [1–6]. Intramedullary nailing is the "gold standard" for their management because of the biomechanical advantages of intramedullary devices [7]. Their distribution is bimodal, with a peak in young males usually secondary to high energy trauma, and a second peak in elderly females, usually secondary to low energy falls [8]. Mortality rates are reported to be as high as 17.3% and are commonly associated with presence of pre-injury co-morbidities [9]. Failure of fixation is directly associated with non-union or mal-union, having a significant impact on the quality of life of such patients by causing additional pain and reduced mobility [10]. The overall cost of treatment and care for patients with hip fractures in the UK is over £2 billion, with revision surgeries for failed fixation inevitably adding to this sum [11].

Risk factors associated with failed fixation of subtrochanteric fractures have been investigated in the literature. Patient factors include quantitative and qualitative bone disease (osteoporosis or metabolic bone disease), infection, smoking and increasing fracture comminution [5,12–14]. Surgical factors include post-operative varus malalignment [10] and lack of continuity of the medial wall [4,15]. More specifically, deficiency of the medial wall can result to the nail acting as a "load bearing" device instead of "load sharing", resulting in high concentration of forces passing through the lag-screw junction, which represents the "weakest" point of the nail [16]. If union does not occur early enough, this results to the breakage of the nail at this area by the process of fatigue failure.

Bone grafting can be used to manage bone defects following fracture fixation and has been shown to increase union in such patients.

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https://doi.org/10.1016/j.tcr.2021.100555
Accepted 25 October 2021
Available online 16 November 2021
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Common options include autologous bone grafts often harvested from the iliac crest, and allografts from donors or demineralised bone matrix. Autografts harvested from the iliac crest is the "gold standard" [17], combining excellent osteogenic, osteoinductive and osteoconductive properties [18]. However, the incidence of donor site morbidity remains high, especially that of chronic pain [17]. To avoid these risks, several types of allografts and xenografts are available. Tutobone® and demineralised bone matrix (DBM) have been extensively used with good results, combining osteoconductive and some osteoinductive properties [19]. Several studies have shown that bone grafting when used alongside internal fixation in patients with subtrochanteric fractures produces high union rates and improves overall function [20].

We present a case of a failed subtrochanteric intramedullary nailing which was managed with exchange nailing and restoration of the medial femoral wall with allogenous bone grafting. We propose that restoring the continuity of the medial wall should be achieved in similar patients in order to enhance healing potential, reduce time to union and restore the biomechanical properties of the subtrochanteric region, reducing the risk of fatigue failure of the fixation device.

Case presentation

An 86-year-old female patient with a background of hypertension and osteopenia treated with yearly Zolendronic acid infusions presented to the Emergency Department of a district general hospital following a low energy fall. She was a non-smoker, non-obese, lived alone, mobilised unaided and was generally very independent. Antero-posterior (AP) and lateral radiographs of the pelvis and left femur demonstrated a left subtrochanteric proximal femoral fracture with comminution of the medial wall and a long spiral element involving the lateral wall. This was an isolated injury that was managed according to the relevant British Orthopaedic Association Standards for Trauma (BOAST) guidelines, subsequently receiving a long cephalomedullary nail (Gamma3 long nail; © Stryker, Mahwah, NJ, USA) with anatomical reduction of the fracture. There was however loss of support of the medial wall secondary to the local comminution. To aid reduction, an open approach to the fracture site was utilised and a cerclage cable (Dall-Miles Recon and Trauma Cable System; © Stryker) was applied. In the early post-operative period, she progressed well with no evidence of any complications and was discharged after a few days.

The patient represented to the local Emergency Department just before her 6-week follow up, reporting her left leg gave way whilst walking, having no history of preceding falls. Further radiographs demonstrated failure of the nail at the lag screw junction in the left femur (Fig. 1). Initial blood tests did not reveal any evidence of infection and her surgical wounds had healed with no problems. Subsequent CT scans of the pelvis and left femur showed incomplete fracture healing with some evidence of callous formation and without any additional pathology. Otherwise, examination was unremarkable. Due to the complexity of this case and according to the local guidance, the patient was referred to our centre for further management.

Treatment

The objective of revision surgery was to restore the anatomy of the subtrochanteric region (particularly avoiding varus malreduction) with a mechanically stable device to allow for early mobilisation. Intra-operatively the broken Gamma nail was removed from the left femur, with the proximal part pulled through the fracture site (as the operating surgeon was unable to engage and remove this from the proximal wound) and the distal part removed using a hook (Fig. 2). Deep tissue samples from the fracture site were obtained and sent for microbiology to exclude low grade infection. A long Affixus nail (Affixus hip fracture nail; Zimmer Biomet™, Warsaw, IN, USA), of a higher diameter (13 mm instead of 11 mm) was then applied. Following reduction and fixation, a 2 cm × 2 cm defect of the medial femoral wall extending anteriorly was evident. Tutobone® chips, a cancellous bovine bone substitute, were applied over the medial/anterior wall defect and covered with a demineralised bone matrix (DBM) sponge (Fig. 3).

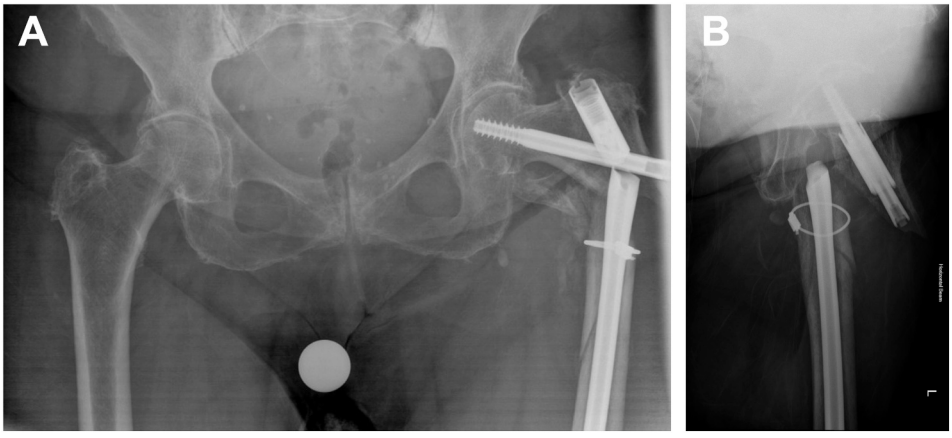

Fig. 1. Plain antero-posterior (AP) radiograph (A) and lateral view (B) demonstrating failure of the intramedullary nail at the lag-screw junction with medial wall comminution.

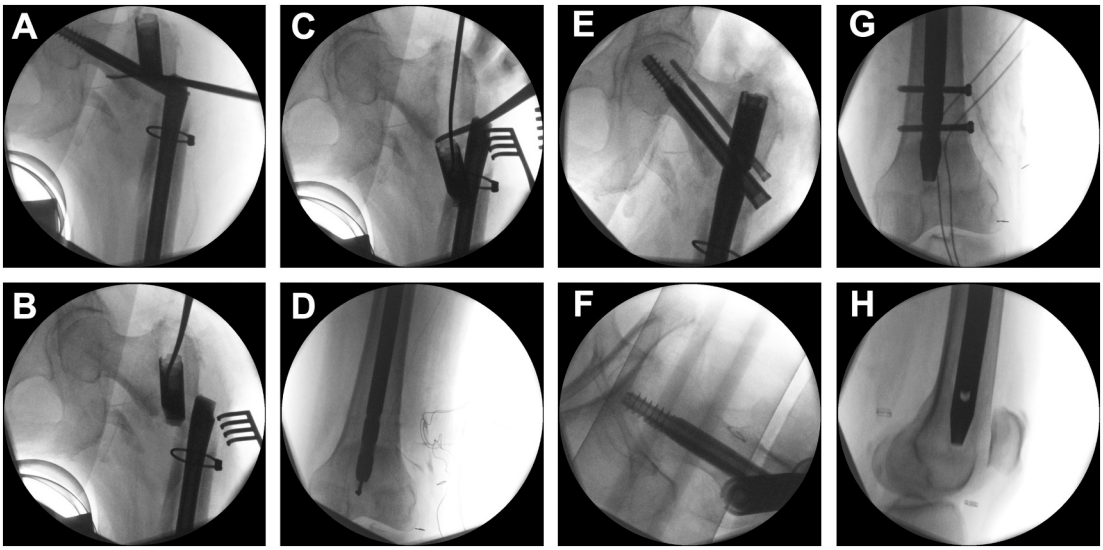

Fig. 2. Intra-operative plain radiographs of the left femur demonstrating removal of the failed intramedullary device (A-D) and insertion of the new larger diameter nail (E-H).

Outcome and follow-up

The immediate postoperative course was mostly uneventful with some mild wound leakage occurring during the first ten days. There was no evidence of surgical site infection and this was attributed to the patient's low blood albumin (22 g/L postoperatively) and was managed with nutritional support and regular dressing changes. Intravenous Teicoplanin was administered as a precaution until intra-operative conventional tissue cultures showed no growth. The patient was initially advised to mobilise by protected weight-bearing for three months and then progressed to full weight-bearing with no further concerns.

Follow up with clinical and radiological assessment was performed at 6 weeks, 12 weeks and 9 months post-operatively (Fig. 4). At the 6 week follow up, plain AP radiographs of the pelvis showed bridging of the femoral calcar and clinical examination revealed good range of movement of the hip and knee which was pain-free. Final follow up at 9 months post-operatively demonstrated full consolidation of the fracture with extensive callus formation around the medial column. Clinically the patient reported no residual limb pain and she had regained her pre-operative mobility and functional status including range of movement of her left hip.

Discussion

The incidence of subtrochanteric femoral fractures has been reported as 15–20 per 100,000 [21], two thirds of which occur in patients over 50 years of age [8]. Increasing age, low total hip bone mineral density and a history of diabetes mellitus are several patient risk factors reported to be associated with an increased risk of sustaining a subtrochanteric fracture [22]. In the elderly population presenting with these injuries, co-morbidities are common; the injury insult along with the subsequent surgery add to the physiological hit and carry a significant impact on the patient's recovery and rehabilitation. A prospective study evaluating the quality of life of patients over 65 years old after sustaining a subtrochanteric fracture found that at 2 years, only 46% of patients had regained

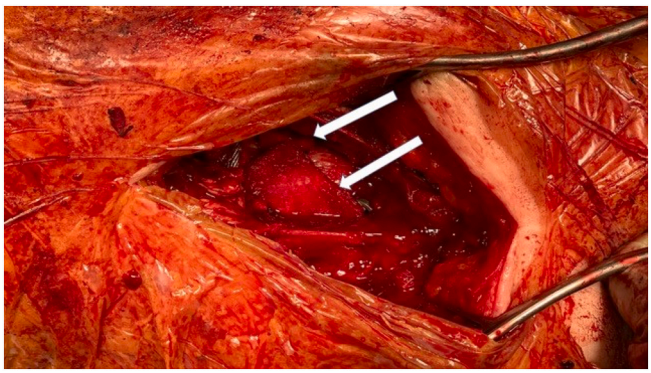

Fig. 3. Intra-operative photograph following the application of Tutobone® and demineralized bone matrix sponge into the medial wall defect.

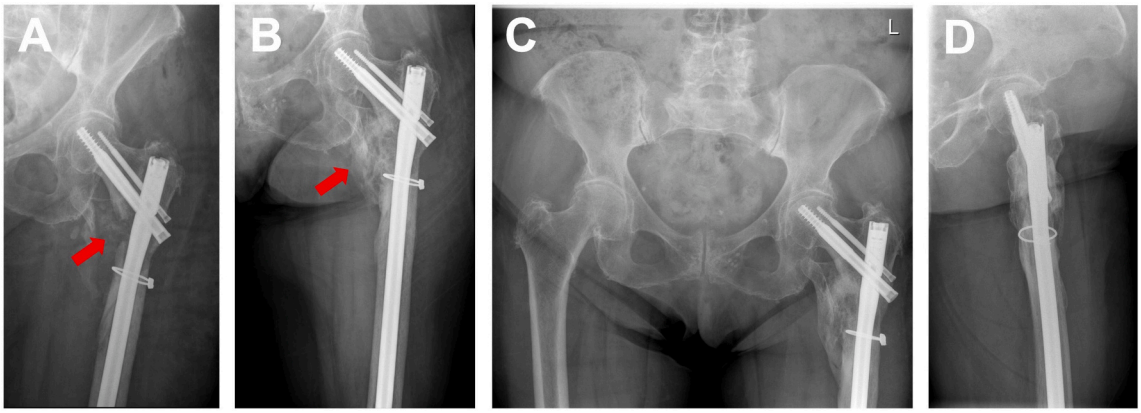

Fig. 4. Plain radiographs of the left proximal femur (A) AP view taken immediately post-operatively and then at (B) 3 months (C and D) 9 months post-operatively (AP and lateral views). The red arrow demonstrates the site of medial wall discontinuity into which Tutobone® and demineralised bone matrix was inserted during revision surgery. (B) shows callus formation and bridging of the femoral calcar as well as callus around the fracture site. By 9 months (C) the fracture line is fully united and the medial femoral wall is restored. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

their pre-injury mobility status and just 48% had the same level of functionality in carrying out their activities of daily living [10]. It is therefore of paramount importance to achieve anatomical reduction and stable fixation of the fracture to provide the best chance of a successful recovery in terms of mobility and quality of life.

The "gold standard" treatment of subtrochanteric fracture is intramedullary nailing [7] because of their biomechanical properties and minimally invasive surgical technique [23]. However, these are difficult fractures to manage and have been associated with the highest mechanical failure rates compared with other types of hip fractures [24]. The insertion of several muscles on the proximal femur creates strong deforming forces that need to be addressed when attempting to reduce the fracture. More specifically, the proximal segment is subjected to tensile forces resulting in either a flexion deformity due to iliopsoas, abduction by the glutei, and external rotation by the short external rotators [25,26]. Muscle attachments acting on the distal segment include the adductors which create a torsional force that can result in varus deformity [27,28]. The lesser trochanter fragment also plays an important role; there is evidence to suggest that an increased distance between the fracture line and lesser trochanter increases the risk of varus deformity and fracture non-union [5]. Varus malalignment due to inadequate reduction can affect bone healing and can result in unfavourable outcomes [15]. Additionally, bone healing is affected by the local blood supply. This region is mainly comprised of hard cortical bone with moderate vascularity, resulting in longer osseous healing times than other regions [23].

Failure of surgical fixation of subtrochanteric fractures has been reported in as high as 20% of cases [1–3], with implant failure occurring in 1.9% of fractures fixed with an intramedullary nail [29]. A study investigating subtrochanteric fracture non-union identified a specific pattern in the mode of metalwork failure: breakage of the distal locking screws ("self-dynamisation") resulting in fracture of the nail at the lag screw junction [30]. The lag screw junction is an important area where load is transmitted from the femoral neck to the diaphysis. As there is a 70% reduction in the cross-sectional area in this part of the nail, this region represents a weak zone where implant failure can occur [30].

Factors contributing towards the incidence of subtrochanteric fracture fixation failure can be divided into patient specific factors and operative factors. Patient specific risk factors observed in our patient, including increasing age and osteopenia, may have played a role in the failed fixation and should not be discounted. Comminution of the medial wall on the other hand was an operative factor also present in our patient and has been associated with failed fixation of subtrochanteric fractures [15].

Lack of medial wall support resulting in impaired healing of subtrochanteric fractures has been well documented in the literature. A study investigating trochanteric and subtrochanteric fracture fixation failure in patients with medial wall discontinuity reported the primary reason for failure of metalwork was lack of postero-medial support and compression of trochanteric fragments causing increased stress on the intramedullary device [31]. This could be explained by fatigue loading of the device due to failed restoration of the medial wall, a finding reported in a meta-analysis by Kuzyk et al. [32]. More specifically, the medial wall of the proximal femur, including the femoral calcar, is subjected to high stress from compressive forces during movement and weight-bearing and is important in counteracting bending forces in this area [16]. Inadequate reduction resulting in postoperative varus malalignment causes increased bending forces on the femoral calcar during weight bearing [15]. Furthermore, disruption of the medial wall due to comminution will affect the intrinsic stability of the device and its ability to resist these forces. As a result, an increased concentration of compressive forces will pass through the device during weight bearing, particularly at the lag screw junction, an area already identified to be a weak point in the device. If the metalwork is unable to counteract these forces whilst the bone heals, this can result in implant fatigue failure [33].

Several studies have reported improved clinical outcomes in patients with fractures reduced with good medial wall cortical support [34–35]. The importance of reconstructing medial column defects caused by comminution to prevent device failure was first described by Schatzker and Waddell in 1980 [1]. They recommended the use of autologous bone grafting for all patients presenting with

subtrochanteric fractures to improve the likelihood of fracture union. The "Diamond concept" incorporates the enhancement of both the mechanical and biological components of fracture treatment to treat non-union of atrophic subtrochanteric fractures in a single stage procedure where metalwork has failed. This is achieved through revised fixation and optimising the fracture environment to encourage bone healing, including bone grafting and the use of growth factors [30]. Our patient was managed according to these principles, with revision fixation incorporating allografts including DBM and Tutobone®, to optimise bone healing. A study evaluating the clinical outcomes of patients presenting with subtrochanteric fracture non-union managed with the "Diamond concept" reported that of the 14 eligible patients, only 1 patient required further revision surgery to achieve fracture union. Furthermore, the most significant outcome was that all patients regained their pre-injury mobility after revision surgery, as seen in our patient [30]. This suggests that combining anatomical reduction and mechanical fixation through revision of metalwork, whilst enhancing the biological environment and reconstituting the medial wall can lead to a successful outcome.

In conclusion, unaddressed medial wall discontinuity in subtrochanteric fractures can lead to failure of metalwork. In these patients, we recommend reconstruction of the medial wall during their primary procedure. By completing this crucial step, the forces through the medial wall and the nail itself are reduced, increasing the likelihood of bony union without the need for further revision surgeries due to implant failure. Restoring the anatomy of the hip improved functionality and mobility in our patient, allowing them to return to their daily activities and maintain their quality of life. Future studies investigating fixation failure of subtrochanteric fractures due to medial wall discontinuity should evaluate patient outcomes after revision surgery where restoration of the medial column is performed, and could potentially assess whether the type of implant used for internal fixation in revision surgery influences time to union and post-operative mobility.

Learning points/take home messages

- Subtrochanteric femoral fractures are challenging to treat, resulting in failed fixation in 7–20% of cases
- One of the leading causes of failure of fixation in such fractures is discontinuity of the medial wall
- Reconstruction of the medial wall utilising bone graft substitutes during revision surgery is biomechanically advantageous and associated with a reduced time to healing
- We therefore recommend addressing medial wall deficiency/comminution during the primary operation to prevent failure of the construct, varus malunion or impaired healing, translating to better patient outcomes and reduced costs

Declaration of competing interest

All authors declare no conflict of interest.

No funding was received for the completion of this project.

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