

Atypical femoral fractures and management of implant failures: a ten-year university hospital case series from Scotland UK

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ABSTRACT

Introduction: The management of osteoporosis continues to evolve, and patients are increasingly prescribed long-term bisphosphonates. Atypical femoral fracture (AFF) has been recently identified and its management remains a challenge with high risk of non-union and subsequent implant failure.

Objectives: To review ten years retrospective data of patients with AFF and surgical management of failure of the implants at University Hospital, Scotland, UK.

Materials & Methods: This is a retrospective review of patients with AFFs from 2009 to 2018 carried out at University Hospital Crosshouse, Kilmarnock, Scotland, UK. Patients were included based on American Society for Bone and Mineral Research (ASBMR) guidelines. Demographic data and use of bisphosphonates were collected from case notes. Postoperative radiographs were reviewed for fracture healing. EQ-5D-5L scoring system was collected over the phone to measure functional outcome of patients. The cases of implant failures which required revision surgery were reviewed.

Results: The study includes 22 patients (26 fractures) with mean age of 75 ± 7.7 years. There were 16 atypical subtrochanteric and 10 atypical femoral shaft fractures. Patients were on Bisphosphonates for a mean of 9.8 ± 3.3 years in 88% cases without any medication holiday. All the fractures were managed with intramedullary nails except one using locking plate fixation. The mean time to complete union in 19 fractures was 9.1 ± 4.7 months (range 4–19 months). Two showed early radiological signs of healing before death. There were two asymptomatic non-unions and three implant failures. The EQ-5D-5L score showed that 65% patients had none or mild pain and mobility was maintained in 88% cases. The implant failures were managed with proximal femoral replacement in two cases and third patient had an osteotomy and dynamic hip screw fixation.

Conclusion: Most of our patients with atypical femoral fractures were on long term bisphosphonates. The surgical management with intramedullary nailing is our recommended first-line of treatment with proximal femoral replacement a viable salvage option.

Keywords: Osteoporosis; Diphosphonates; Osteoporotic Fractures; Femoral Fractures.

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INTRODUCTION

Fragility fractures are currently one of the major concerns in elderly population with life-time risk of up to 50% in women and 25% in men.¹ Bisphosphonates (BPs) have been shown to reduce the risk of osteoporotic fractures. The current national guidelines in UK from National Institute of Clinical Excellence² and Scottish Intercollegiate Guidelines Network (SIGN 142)³ recommends use of BPs for prevention of these fractures. However, these medications may result in Atypical Femoral Fractures (AFF) and in addition affect the fracture healing process. In a large population-based study Park-Wyllie reported that the overall incidence of AFFs was found to be 0.35% which is far less when compared to overall incidence of typical proximal neck of femur fractures.^{4,5}

The American Society for Bone and Mineral Research (ASBMR) definition of AFFs was revised in 2014 (Table 1).^{6,7}

Table 1: ASBMR 2103 case definition of AFFs

- The fracture must be located along the femoral diaphysis from just distal to the lesser trochanter to just proximal to the supracondylar flare.
- In addition, at least four of five Major Features must be present.
- None of the Minor Features is required but have sometimes been associated with these fractures.

Major features

1. Fracture is associated with minimal or no trauma, as in a fall from a standing height or less.
2. Fracture line originates at the lateral cortex and is substantially transverse in its orientation, although it may become oblique as it progresses medially across the femur.
3. Complete fractures extend through both cortices and may be associated with a medial spike; incomplete fractures involve only the lateral cortex.
4. The fracture is noncomminuted or minimally comminuted.
5. Localized periosteal or endosteal thickening of the lateral cortex is present at the fracture site ("beaking" or "flaring").

Minor features

1. Generalized increase in cortical thickness of the femoral diaphyses.
2. Unilateral or bilateral prodromal symptoms such as dull or aching pain in the groin or thigh.
3. Bilateral incomplete or complete femoral diaphysis fractures.
4. Delayed fracture healing.

The most sensitive differentiating features for the diagnosis of AFFs were lateral transverse fracture pattern (93%), medial cortex transverse or oblique fracture pattern (84%), and minimal or no comminution (93%). The most specific feature was transverse fracture pattern of lateral cortex (95%).⁷ The literature review shows a significant association between AFFs and BPs. It has been identified that there is a high relative risk but a low absolute risk with the use of BPs.⁸ The evidence proposes that AFFs are insufficiency or stress fractures. The histopathological studies show changes in extracellular bone matrix and suppression of healing of microfractures due to lack of target remodelling in the BPs treated patients.⁹ Lower limb geometry has also been reported as a possible contributing factor in studies carried out in different ethnic groups.¹⁰

Delayed union, non-union and implant failure were experienced in our department. We suspected that implants used for fixation of AFFs may have failed not only due to issues with implants, but in addition also secondary to poor bone healing potential in patients on BPs. This study is a case series of patients with AFFs and our experience of surgical management of the implant failures.

MATERIALS & METHODS

The 2014 ASBMR guidelines were followed to identify AFFs. We excluded fractures secondary to metabolic bone disorders, malignancy, periprosthetic fractures, fractures caused by high-energy trauma, intertrochanteric fractures and fracture extending into distal metaphysis. This study was carried out at University Hospital Crosshouse, Kilmarnock, Scotland, UK. Data were collected from case notes which included: 1) demographics, 2) bisphosphonates and steroid use, 3) location of the fracture, 4) time to union. EQ-5D-5L scoring system was used to measure functional outcome of patients and was collected over the phone at the final follow-up. The components of this questionnaire are pain, self-care, usual activities, mobility, and anxiety/depression. These components were scored on scale of 1) no problem, 2) minimal, 3) moderate, 4) severe problem, and 5) inability. The cases which showed radiological signs of healing but died before completion of fracture union were included in the study. The failure of implants and subsequent management of these patients were reviewed in detail. There was no funding received for this study by department or any of the author.

RESULTS

A total of 282 patients were identified with femoral fractures from 2009 to 2018; 22 patients with 26 AFFs were included in this study.

The mean age was 75 ± 7.7 years (range 57 - 87years); 25 patients were female and only one was male. There were 16 atypical subtrochanteric and 10 atypical femoral shaft fractures. BPs were used for long-term in 17 (77.3%) patients. Two patients (09.1%) were on combination of BP and steroids. Two other patients (09.1%) were only on long-term steroids. The pharmacological records were missing in one case. In total 88% fractures were on BPs for 4 to 15 years with mean of 9.8 ± 3.3 years. None of the patients had a BPs medication holiday (Table 2).

Table-2: Demographics and use of Medications (n=22).

| No of Fractures | 26 |
|--------------------------------|----------|
| Age (Years) | |
| Mean | 75 ± 7.7 |
| Range | 57 - 87 |
| Gender | |
| Female | 21 |
| Male | 01 |
| Pharmacological record | |
| Bisphosphonates (BPs) | 17 |
| Steroids | 2 |
| BPs + Steroid | 2 |
| Pharmacological record missing | 1 |

The Functional assessment using EQ-5D-5L scoring system at final follow-up was available in 17 fractures (Figure 1). The outcomes showed eleven (65%) had no or mild pain and six had moderate pain. 11 out of 17 had none or mild impairment of mobility and 4 had moderate issues. The mobility was maintained in 15 (88%), out of which eight patients (47%) were not using any walking aids. Only two were using wheelchair while outdoors: one was due to extensive heterotrophic ossification and second patient was recovering after proximal femoral replacement. Majority of these patients were able to carry out usual daily activities and self-care with none to mild issues, three had moderate problems and two reported severe problems.

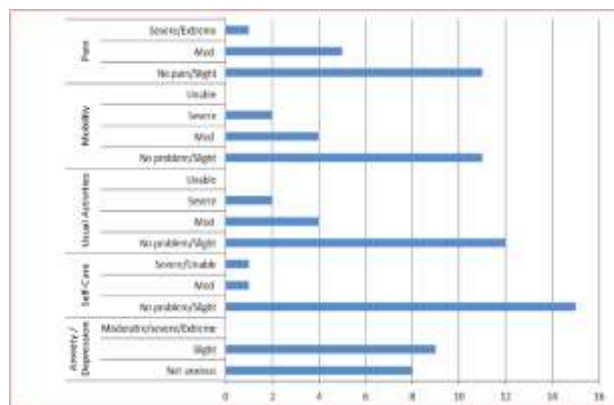


Figure 1: Functional outcomes based on EQ-5D-5L scoring.

Seven patients (26%) had prodromal symptoms with pain in the groin or thigh. The AFFs were managed using cephalomedullary nail (Gamma, Stryker, Mahwah, NJ, USA; Biomet, Warsaw, IN, USA) in 22 fractures (84%). Expert lateral femoral nail (Depuy Synthes, Synthes GmbH Eimattstrasse, Oberdorf, Switzerland) was used in three cases of AFFs (12%). One patient had first attempt with proximal femoral locking plate (Stryker, Mahwah, NJ, USA; Biomet, Warsaw, IN, USA), the details are provided later. Complete fracture union occurred in 19 out of 26 fractures, mean time to union was of 9.1 (4 to 19) months. Rest of the nine fractures (Table-3) showed: early callus formation (2), asymptomatic non-unions (2), and implant failures (3).

The review of six patients who died in this case series showed all these mortalities were secondary to their comorbidities. One patient had pain and radiograph showed localised beaking and periosteal changes in the femur which was initially treated non-operatively due history of congestive cardiac failure, sarcoidosis,

and cholangiocarcinoma. She had a fall and developed a displaced atypical femoral shaft fracture which was managed with Gamma Nail. This was showing early signs of healing but unfortunately patient died of a cardiac arrest at three months post-operatively. Second patient with multiple co-morbidities had bilateral fractures and she died due to a cardiac event. She had one fracture which healed at 18 months and second was showing early callus. Third patient died of endometrial carcinoma two

years after the bilateral AFFs. The fractures in this case united at 14 and 19 months. Fourth patient died of pulmonary fibrosis four years later, fracture healed at nine months. Fifth patient died of a cardiac event two years after the fracture, fracture healed at six months. The sixth patient has died recently; she had asymptomatic non-union and died four years after the surgery secondary to a stroke (Table 3).

Table 3: Summary of the patients in the study.
(Bilateral AFFs are mentioned in Bold and non-unions were asymptomatic)

| # | Gender | Age (years) | Bisphosphonates (years) | Fracture type | Implant | Time to Union (Months) | Died |
|----|---------------|-------------|-------------------------|------------------------|-----------------------------|------------------------|------------|
| 1 | Female | 87 | 11 | Femoral Shaft | Lateral Femoral nail | 6 | |
| 2 | Female | 80 | 8 | Femoral Shaft | Gamma Nail | 4 | |
| 3 | Female | 79 | 8 | Femoral Shaft | Lateral Femoral nail | 10 | |
| 4 | Female | 76 | 15 | Subtrochanteric | Gamma Nail | Implant failure | |
| 5 | Female | 79 | 8 | Femoral Shaft | Gamma Nail | 4 | |
| 6 | Female | 58 | 10 | Subtrochanteric | Gamma Nail | 9 | |
| 7 | Female | 77 | 4 | Subtrochanteric | Gamma Nail | Non-Union | |
| 8 | Female | 75 | 10 | Femoral Shaft | Gamma Nail | 9 | Yes |
| 9 | Female | 80 | 12 | Femoral Shaft | Gamma Nail | 13 | |
| 10 | Female | 79 | 5 | Femoral Shaft | Gamma Nail | 19 | Yes |
| 11 | Female | 79 | 5 | Femoral Shaft | Gamma Nail | 14 | Yes |
| 12 | Male | 66 | No | Subtrochanteric | Gamma Nail | Implant failure | |
| 13 | Female | 82 | 10 | Subtrochanteric | Gamma Nail | Non-Union | Yes |
| 14 | Female | 71 | 15 | Subtrochanteric | Gamma Nail | 14 | |
| 15 | Female | 71 | 15 | Subtrochanteric | Gamma Nail | 9 | |
| 16 | Female | 64 | 11 | Subtrochanteric | Gamma Nail | 14 | |
| 17 | Female | 86 | No Record | Subtrochanteric | Gamma Nail | 6 | Yes |
| 18 | Female | 75 | 5 | Subtrochanteric | Gamma Nail | 8 | |
| 19 | Female | 82 | 13 | Subtrochanteric | Gamma Nail | Early callus | Yes |
| 20 | Female | 78 | 13 | Subtrochanteric | Gamma Nail | 18 | Yes |
| 21 | Female | 57 | 12 | Subtrochanteric | Gamma Nail | 6 | |
| 22 | Female | 84 | No records | Femoral Shaft | Lateral Femoral nail | 7 | |
| 23 | Female | 85 | No | Subtrochanteric | Gamma Nail | 4 | |
| 24 | Female | 76 | 11 | Femoral Shaft | Gamma Nail | Early callus | Yes |
| 25 | Female | 68 | No | Subtrochanteric | Gamma Nail | 4 | |
| 26 | Female | 75 | 11 | Subtrochanteric | Locking plate | Implant failure | |

The implant failures which were experienced during the study were: One patient with atypical subtrochanteric fracture had failure of Gamma nail at cervical screw-nail interface at three months from fixation. There was significant loss of bone in the greater trochanter region therefore this was revised to a proximal femoral replacement with a captive cup for the acetabulum. This patient developed extensive heterotrophic ossification postoperatively which affected his functional outcome (Figure 2).

Figure 2: Patient showing development of extensive heterotrophic calcification.

Case 1: Atypical subtrochanteric femoral fracture managed initially with an intramedullary nail. Implant failure revised to proximal femoral replacement. Patient developed extensive heterotrophic calcification.



Second case of implant failure was known to have rheumatoid arthritis. This patient previously had fusion of the ipsilateral knee joint approximately 10 years back following a prosthetic joint infection. The fusion was carried out with an intramedullary device extending halfway up the femur. The patient sustained an atypical subtrochanteric fracture which was fixed initially with a proximal femoral locking plate. This fixation failed after one month and was revised using a Dynamic Condylar Screw with an augmentation plate. This fixation also failed after a month. As a salvage, a proximal femoral replacement with strut bone graft and a captive cup was performed (Figure 3).

Figure 3: Patient with implant failure suffering from Rheumatoid Arthritis.

Case 2: Patient with known Rheumatoid Arthritis and previous knee fusion presented with sub-trochanteric fracture. Treated with proximal locking plate and then DCS with augmentation plate; both these implants failed within a month of fracture. Finally, it was revised with proximal femoral replacement with captive cup.



Third patient presented at three months with Gamma Nail fatigue failure which was performed for atypical subtrochanteric fracture. This was revised with an excisional osteotomy at the fracture site and fixation with Dynamic Hip Screw (DHS). The excisional osteotomy has proven in the histological studies that removed bone ends have poor healing potential^{6,7,9}. In addition, we believe that the osteotomy also allows conversion of an oblique fracture pattern into a more stable transverse bone ends which should reduce shear forces (Figure 4).

Figure 4: Patient with Gamma Nail Fatigue syndrome.

Case 3: Atypical femoral subtrochanteric fracture initially managed with Gamma Nail. Revision with Subtrochanteric Osteotomy, bone grafting and DHS plate.

Another complication was experienced, where a patient had initial treatment of atypical femoral shaft fracture with an Expert lateral femoral intramedullary nail with no cervical screws into the neck of femur. The fracture fully united at seven months. However, later at nineteen months, patient sustained a traumatic intracapsular neck of femur fracture. This was managed by removal of that nail and conversion to a cemented total hip arthroplasty augmented by a locking plate to bridge the previous fracture site (Figure 5).

Figure 5: Patient with traumatic intracapsular neck of femur fracture.

Case 4: Initially successfully treated for atypical femoral shaft fracture with Expert lateral femoral intramedullary nail without cervical screws. Subsequent traumatic intracapsular neck of femur fracture at nineteen months post op; managed by nail removal and conversion to cemented total hip arthroplasty with locking plate.



DISCUSSION

The incidence of femoral neck fractures in the elderly population are reported to decrease significantly from 242 per 100,000 in 2003 to 146 in 2013 in a study by Ju et al.¹¹ This has been attributed to bisphosphonate use, public health awareness with weight-bearing exercises, bone densitometry and decreased smoking. Recent study by Black et al based-on review of three large scale randomised control trials using Alendronic acid and Zoledronic acid with a placebo-control group reported that risk of the AFFs was significantly low.⁸ Similar findings were shown by a population-based study from the Danish registry.¹² However, there are concerns that the long-term use of BPs can result in AFFs.¹³ Current guidelines recommend reevaluation of patients on BPs after 5 years to consider alternative treatment or medication holiday. Patients are advised to report any thigh or hip pain during treatment with BPs.¹⁴

In our study 86% of the patients were on BPs. There were subtrochanteric fractures in 61%, middle third fractures in 39% and no fracture in the distal third. Beaking was not obvious on radiographs in few cases but noted intra-operatively and in addition the fracture edges were sclerotic, even though it was not a delayed presentation. Hagino et al¹⁵ reported a survey by Japanese orthopaedic association of 230 AFFs which is the largest series of patients with AFFs so far. They showed that 75% patients were treated with BPs and 19.6% were not on BPs. The duration of use was three years or longer in 59.5% and between one and three years in 13%. Beaking on radiographs was noted more frequently in patients treated with BPs (86%). The distribution of fractures in the femoral shaft showed that middle third shaft fractures were the commonest (68.3%) followed by 30.4% in proximal third and only 1.3% in distal third.¹⁵

A recent systematic review from Koh et al showed that time to healing in AFFs was 7.3 months and higher rate of failure was reported in fractures fixed with plates (31.3%) compared to intramedullary nails (12%).¹⁶ In our study all the fractures were managed with intramedullary nails (25) except one using locking plate fixation. The mean time to complete union in 18 fractures was 9.1 ± 4.7 months (range 4 – 19 months). There were two asymptomatic non-unions and three implant failures. Three showed early radiological signs of healing before death. The studies based on failures of different generations of Gamma nails have shown that majority were short gamma nails and occurred at 4 to 15 months. The nails usually fail at the cervical screw-nail interface, where it is 73% thinner. Other studies have shown pathological fractures, varus malalignment, calcar deficiency, fracture gap >5mm, subtrochanteric fracture, lower ASA and younger patient as causes of the failures.¹⁷⁻²¹ Egol et al showed lack of anatomical reduction of the fracture in 36% of the cases and this resulted in 3.7 months longer to achieve union.¹ In our study, two patients had failure of Gamma nails in the atypical subtrochanteric fractures. Gamma nail fixations in both these cases had anatomical reduction, bony apposition at three out of four cortices and no varus malalignment. The implant failure occurred at cervical screw-nail interface at 3 months which is line with the literature. There were no other factors identified for

implant failures in our study apart from the sub-trochanteric location of the fracture.

The literature search showed that authors have tried different surgical techniques to enhance the chances of fracture healing. Bogl et al treated the fractures with intramedullary nails and in addition carried out resection of the affected cortical bone at the fracture site using a cylindrical drill (diameter 11.5 mm). They showed complete cortical bridging at a mean of 7 months in a series of 8 cases.²² A study of atypical subtrochanteric fractures by Kulachote showed shorter healing time and less cases of delayed union in a group of patients treated with Demineralised Bone Matrix (DBM) compared to a control group without DBM treatment. Both groups also received a course of anabolic treatment (Teriparatide or Strontium Renalate) postoperatively.²³ Miyakoshi also showed similar findings in their retrospective review comparing AFFs treated with to without teriparatide.²⁴ In our experience we were successful in revising one of the failed Gamma nails by excisional osteotomy of the fracture surfaces and fixation using a DHS with a long plate.

Non-operative treatment of incomplete AFFs has been shown to result in failures up to 47% in the review by Koh et al and the authors recommended prophylactic fixation of symptomatic patients.¹⁶ Ha et al also found that none of the patients in their study had spontaneous healing of incomplete fractures or resolution of pain. Surgical treatment was carried out in 10 fractures (71%). While the patients who refused to undergo surgery had persistent pain.²⁵ Lateral plate fixation has been described by Kharazmi et al in patients with incomplete atypical AFFs with lateral femoral bowing to create a tension band effect.²⁶ Banffy et al showed shorter hospital stay and no complications in prophylactic nailing group. Whereas those patients when presented after fracture completion: one had a non-union requiring a further procedure and another had delayed union.²⁷ Thus, non-operative treatment should not be recommended, but if need be then these patients should be closely followed up. In our series one patient was initially treated non-operatively due to medical co-morbidities. Subsequently had a fall which resulted in completion and displacement of the fracture which was then managed with a Gamma nail.

The population-based case control study by Park-Willye et al showed that approximately 10% of AFFs might be prevented if patients do not receive more than 5 years of BPs. However, the studies continue to support that benefits of prevention of fragility fractures with BPs use continue to outweigh the risk of AFF.^{6,7} The optimal duration of BPs therapy is yet to be established. Thus, to avoid AFFs it may be appropriate to consider a medication holiday from BPs for selected patients.^{17,28}

There are a number of limitations to our study. We were unable to consistently gather co-variables such as smoking status, and body mass index from the case notes. Furthermore, our study was of a retrospective design with a small sample size. We were unable to collect functional outcomes and fracture union time in all of our patients.

CONCLUSION

This case series shows that Atypical Femoral Fractures are associated with long-term use of bisphosphonates in the majority of patients. Cephalomedullary nailing is recommended as the first line of treatment for both atypical femoral shaft and

subtrochanteric fractures. Plate fixation can be performed only in selected cases when nailing is not feasible. Proximal femoral replacement remains a viable salvage option.

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