

Retrospective evaluation of atypical periprosthetic femoral fractures and its associated risk factors

Author 1:

Name: Dr. SAMUDRALA SREENIVAS

Designation: ASSOCIATE PROFESSOR

Department: Orthopaedics

**Name of Institute: RVM INSTITUTE OF MEDICAL SCIENCES & RESEARCH
CENTRE**

Email: sreenuortho@gmail.com

Author 2 & Corresponding:

Name: Dr. SAINATH REDDY MANDA

Designation: ASSISTANT PROFESSOR

Department: Orthopaedics

**Name of Institute: RVM INSTITUTE OF MEDICAL SCIENCES & RESEARCH
CENTRE**

Email: sainathreddymanda@gmail.com

Author 3:

Name: Dr. SAMUDRALA VIPANCHI

Designation: Junior Resident

**Name of Institute: RVM INSTITUTE OF MEDICAL SCIENCES & RESEARCH
CENTRE**

Email: sreenuortho@gmail.com

Mobile: 09133343726

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Abstract

Aim: To evaluate atypical periprosthetic femoral fractures, its outcomes and its associated risk factors.

Methodology: This is a retrospective observational study carried out during duration of 2 years (April 2020 - March, 2022 at the Traumatology Department of college. All consecutive adult patients admitted with subtrochanteric or shaft fractures were evaluated with respect to the following inclusion and exclusion criteria. Inclusion criteria are based on the clinical and radiological features of AFF as defined by the American Society for Bone and Mineral Research major criteria. During the study period, 90 patients with subtrochanteric or femoral shaft fractures treated in the hospital that met the inclusion criteria. Of these, 10 patients had bilateral fractures on presentation. Surgeries were performed by trauma surgeons, and patients underwent standard rehabilitation following the procedure. Demographic information and surgical details were recorded from the hospital electronic records. The quality of reduction was evaluated by the

postoperative standard X-rays in the anteroposterior (AP) and lateral views using digital pictures.

Results: The average age of the patients was 64.2 years, with the majority being female (87.8%). In all, 91.1% of them walked independently prior to the fracture. The most common BP used was alendronate by 63.3% of patients. There were 43% subtrochanteric fractures and 57% femoral shaft fractures. The mean operative time was 110 minutes (range: 42-205 minutes; SD = 50 minutes). Closed reduction was performed in 62% of fractures, whereas 34% required some form of open reduction using minor incisions and fracture manipulation with instruments. The majority underwent intramedullary nailing (90%) with the remaining with plate fixation. In terms of complications, there were 3 intraoperative fractures or perforation of femoral cortex. Otherwise 5 patients had procedure-related complications including broken screw in 1 patient, superficial wound infection in 3 patients, and postoperative foot drop in 1 patient. There were a total of 6 reoperations and 8 non-union, affecting a total of 14 fractures.

Conclusion: APFFs are uncommon periprosthetic fractures that share some unique features with AFFs, including patients' characteristics and fracture-related complications. Early diagnosis and prompt, appropriate treatment are the keys to successful treatment. This study shows that the common patient characteristic in APFFs is using long-term bisphosphonates. APFFs show a poor fracture healing potential and require special attention.

Keywords: Periprosthetic, femoral, Bisphosphonates, Sub-trochanteric.

Introduction:

Atypical femoral fracture (AFF) is a stress fracture occurring with low energy or no trauma and it has a characteristic radiographic appearance [1]. With atypical subtrochanteric and middle third femoral fractures, periprosthetic fractures should be treated as exclusion criteria based on the recommendation of the American Society for Bone and Mineral Research, published in 2014 [1]. Atypical periprosthetic femoral fractures (APFFs) are prevalent in the older generation because it is common to have joint implants in this population, they more likely to suffer from osteoporosis, and to have other comorbidities (e.g., diabetes, vitamin D deficiency and the use of the proton pump inhibitor) in their medical record [2].

Bisphosphonates (BPs) are one of the most commonly used osteoporotic drugs because of their proven efficacy to reduce the incidence of fragility fractures [3]. However, long-term use of BPs can cause a condition called severe suppression of bone turnover (SSBT), resulting in complications such as atypical femoral fractures (AFFs). The prevalence of atypical periprosthetic femoral fractures (APFFs) in patients with hip and knee arthroplasties is currently unknown, as are the associated characteristics and the risk factors for such fractures.

Atypical femoral fractures have also been demonstrated to have a high risk of complications. Reports have indicated that these fractures are more difficult to treat surgically, more prone to delayed healing or nonunion, and have a higher incidence of implant failure and reoperations when compared to the usual femoral fractures [4-7]. In Weil et al's series, there was an alarming

surgical revision rates of 46% [7] and in Teo et al's retrospective review 33% [4]. However, the risk factors for developing these complications are not well known.

As it is a relatively rare condition and with a lack of randomized controlled trials, there is no strong evidence to guide the management of AFF [8]. Expert opinions suggest a multidisciplinary approach, including discontinuation of bisphosphonates (BPs), adequate calcium and vitamin D, and consideration of teriparatide, a recombinant form of parathyroid hormone, as adjuvant [9, 10]. Surgical intervention has been emphasized in treating AFFs, and techniques that allow for endochondral ossification, such as intramedullary nailing and bridging plate, are recommended [8]. The aim of this study was to evaluate atypical periprosthetic femoral fractures, its outcomes and its associated risk factors.

Methodology:

This is a retrospective observational study carried out during duration of 2 years (April 2020 - March, 2022) at the Traumatology Department of college. All consecutive adult patients admitted with subtrochanteric or shaft fractures were evaluated with respect to the following inclusion and exclusion criteria. Inclusion criteria are based on the clinical and radiological features of AFF as defined by the American Society for Bone and Mineral Research major criteria given below.

Fracture located along the femoral diaphysis from just distal to the lesser trochanter to just proximal to the supracondylar flare, in the presence of at least 4 of 5 major features:

- The fracture is associated with minimal or no trauma, as in a fall from a standing height of less
- The 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
- Complete fractures extend through both cortices and may be associated with a medial spike; incomplete fractures involve only the lateral cortex
- The fracture is noncomminuted or minimally comminuted
- Localized periosteal or endosteal thickening of the lateral cortex is present at the fracture sites ("beaking" or "flaring")

Patients were excluded if they did not have a minimum follow up of 1 year or if they had pathological features not related to atypical fracture or osteoporosis.

During the study period, 90 patients with subtrochanteric or femoral shaft fractures treated in the hospital that met the inclusion criteria. Of these, 10 patients had bilateral fractures on presentation. Surgeries were performed by trauma surgeons, and patients underwent standard rehabilitation following the procedure. Demographic information and surgical details were recorded from the hospital electronic records. The quality of reduction was evaluated by the postoperative standard X-rays in the anteroposterior (AP) and lateral views using digital pictures. This method is based on both residual displacement and angulation at the fracture site after fixation; reduction is classified as good (both maximal cortical displacement <4 mm and angulation <10°), acceptable (either maximal cortical displacement <4 mm or angulation <10°), or poor (maximal cortical displacement >4 mm and angulation >10°) [11].

All patients had follow-up duration of at least 12 months. The primary outcome measure is the failure of treatment, defined as either reoperation or nonunion at 12 months. Reoperation is defined as any unplanned operation of the same limb following the index operation, excluding planned staged approach for initial fracture management. Nonunion is defined as the absence of bridging callus on 3 of 4 cortices on AP and lateral X-ray views. Procedure-related complications and mortality within 1 year were also recorded.

Results:

The average age of the patients was 64.2 years, with the majority being female (87.8%). In all, 91.1% of them walked independently prior to the fracture. The most common BP used was alendronate by 63.3% of patients. There were 43% subtrochanteric fractures and 57% femoral shaft fractures.

Variables		Number
Age (in years)		64.2 ± 11.7
Gender	Male	11 (12.2%)
	Female	79 (87.8%)
Baseline mobility	Independent	82 (91.1%)
	Assisted	08 (8.9%)
Bisphosphonate	Alendronate	57 (63.3%)
	Others	28 (31.1%)
	Unknown	05 (5.6%)

Fracture Site	Right	44 (44%)
	Left	66 (66%)
Type of fracture	Displaced	75 (75%)
	Undisplaced incomplete	25 (25%)
Fracture	Subtrochanteric	43 (43%)
	Femoral shaft	57 (57%)

The mean operative time was 110 minutes (range: 42-205 minutes; SD = 50 minutes). Closed reduction was performed in 62% of fractures, whereas 34% required some form of open reduction using minor incisions and fracture manipulation with instruments. The majority underwent intramedullary nailing (90%) with the remaining with plate fixation. Locking compression plates were used in 3 incomplete femur shaft fractures, spanning the whole femur with minimal invasive plate osteosynthesis technique. 2 patients had periprosthetic AFF and required a formal open reduction. The patients who had periprosthetic AFF had a history of hemiarthroplasty many years ago for fragility hip fracture and a history of ipsilateral total knee replacement for degenerative joint disease, respectively. A formal open reduction with locking cable plate spanning the whole femur shaft was used, proximally with 3 screws and cables and distally 6 locking screws. There were 4 other fractures with supplementary fixation with cerclage and 2 with bone graft/substitute as augmentation.

In terms of complications, there were 3 intraoperative fractures or perforation of femoral cortex. Otherwise 5 patients had procedure-related complications including broken screw in 1 patient, superficial wound infection in 3 patients, and postoperative foot drop in 1 patient. Regarding our primary outcome measures, there were a total of 6 reoperations and 8 non-union, affecting a total of 14 fractures. Among the 6 re-operations, 4 were due to nonunion: 1 of these patients underwent revision fixation and 1 underwent dynamization.

The quality of reduction is based on Hoskins' modification of Baumgartner criteria for subtrochanteric fractures [11, 12] and classified as good (both maximal cortical displacement <4

mm and angulation $<10^\circ$), acceptable (either maximal cortical displacement <4 mm or angulation $<10^\circ$), or poor (maximal cortical displacement >4 mm and angulation $>10^\circ$).

	Poor	Acceptable	Good
Failure (14%)	3 (%)	5 (%)	6 (%)
No Failure (86%)	5 (%)	10 (%)	71 (%)
Total (100%)	8	15	77

Discussion:

APFFs are fractures characterized by atypical features of AFFs and occur around femoral stem prostheses. Although both APFFs and AFFs would have a theoretically similar pathogenesis, only a few studies have addressed APFF patient characteristic, and previous studies showed that APFFs had significantly higher fracture-related complications compared to AFFs [13] or typical PFFs [14, 15]. This study aimed to present a case series of five APFF patients and APFF treatment from our experiences. We also reviewed the literature related to the treatment outcome of APFFs and developed an up-to-date treatment strategy.

In our study, we looked at the quality of operative reduction under strict criteria by the Hoskins' modification of Baumgartner criteria for subtrochanteric fractures[11, 12] and found that good reduction with both <4 mm maximal cortical displacement and angulation $<10^\circ$ is associated with lower failure rates. The benefit of using these criteria compared to the cutoff values quoted in previous studies is the ease of implementation intraoperatively using image intensifier. The addition of open reduction also appears to be beneficial ($P = .04$), likely through facilitating a more anatomical reduction. Hoskins et al suggested that the supplementation with cerclage wire statistically improves the fracture displacement, angulation, and quality of reduction in common subtrochanteric fractures [11].

In contrast to the series reported by Teo et al's with a surgical revision rate of 33% [16], our series demonstrated better surgical outcomes. One contributing factors of their high reoperation rate could be due to the use of plates instead of intramedullary fixation devices. Our study reported a similar failure rate as that of a systematic review by Koh et al, where the revision surgery due to delayed union, nonunion, or implant failure was 12.6% [17]. A study by Prasarn et al demonstrated an alarming 44% major complication rates in his series of atypical fractures, but 40% of those fractures were treated with plate fixation [18]. His group observed that there were higher rates of implant failure when plates were chosen as the fixation device. Indeed Koh et al have demonstrated that there was a significantly greater percentage of revision surgery in those treated with plate fixation (31.3%) compared to intramedullary nailing (12.9%, $P < .01$) in his systematic review [17]. Thus, many studies now advocate intramedullary fixation as the main surgical device in the management of AFF.

Another possible modifiable variable that predicts the failure of AFF fixation is the quality of operative reduction. Egol et al noted that a varus malreduction at the fracture site had negative impact on healing; specifically those fixed in varus required an average of 3.7 months more to heal compared to anatomically reduced fractures [19]. Another extensive study by Lim et al also demonstrated the importance of anatomical reduction in healing of AFF [20]. Similarly, Cho et

al's group showed that the quality of reduction is an important factor for healing and time to union [21]. They recommended cutoff values for measuring reduction for successful healing: neck-shaft angle greater than 125.6°, difference in neck-shaft angle with the normal side of less than 4.4°, and sagittal angulation less than 5.5°.

Conclusion:

APFFs are uncommon periprosthetic fractures that share some unique features with AFFs, including patients' characteristics and fracture-related complications. Early diagnosis and prompt, appropriate treatment are the keys to successful treatment. This study shows that the common patient characteristic in APFFs is using long-term bisphosphonates. APFFs show a poor fracture healing potential and require special attention.

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