Periprosthetic Fractures of the Femur after Total Hip Arthroplasty and Hemiarthroplasty: A Review

Reilly R. Kuehn, MD

Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center

Abstract

Periprosthetic fractures of the femur after total hip arthroplasty (THA) and hemiarthroplasty represent relatively uncommon but challenging complications. The incidence of these types of fractures has been rising, owing to an increasing number of hip arthroplasties performed, aging population, and prevalent use of uncemented stems, which may have unsuccessful long-term results compared with use of cemented stems. Method of treatment has been generally based on the Vancouver classification system that describes radiographic characteristics of fractures and stability of the femoral stems in respect to placement in the bone. In particular, the presence of loose stems has often indicated the need for revision THA; on the other hand, fractures located around and distal to well-fixed stems typically have been treated with open reduction and internal fixation (ORIF). The failure to preoperatively identify loose stems may result in unsuccessful treatment with ORIF. I reviewed clinical evaluation, mortality rates, and treatment of patients with Vancouver types A, B1, B2, B3, and C periprosthetic femur fractures. Appropriate treatment of these challenging injuries requires high-level surgical technique, ranging from use of biologically-friendly methods to performing complex revision THA.

Introduction

After total hip arthroplasty (THA) and hemiarthroplasty, periprosthetic fractures of the femur may occur and represent a challenging problem for patients and surgeons. Most periprosthetic femur fractures result from a fall while in sitting or standing positions, with less than 10% of fractures occurring after a high-energy trauma.[1] Risk factors for periprosthetic femur fractures in patients include female sex, osteoporosis, older age, inflammatory arthropathies, and bone deformity.[2] Notably, loosening of previous stems used in THA has recently emerged as a considerable risk factor for these fractures.[3,4]

The prevalence of periprosthetic femur fractures has been rising, possibly owing to the aging population and increasing number of THA performed each year.[5] Fractures occurring intraoperatively during primary THA range from 0.1% to 1% and 0.3% to 5.4% with use of cemented and uncemented stems, respectively. On the other hand, fractures after revision THA occur more frequently, ranging between 3.6% and 20.9%.[6] In particular, although relatively low, the incidence rate of periprosthetic fractures identified years after primary THA (0.1%–7.8%) has been reported as increasing.[6,7] Proposed explanations for this include increased longevity of the population, high level of activity at older ages, and use of uncemented stems during the initial procedure.[6] To help identify effective techniques in treating periprosthetic femur fractures after revision THA and hemiarthroplasty, I reviewed common clinical evaluation, current mortality rates, and operative and nonoperative methods for treatment based on classification of the fracture.

Clinical Evaluation

Use of medical records of the patient can help in selecting the appropriate technique and type of implant used. In diagnosing periprosthetic femur fractures after THA and hemiarthroplasty, the pertinent aspects of patient medical history include functionality level before injury, pre-existing pain, systemic signs of infection, presence of comorbidities, and mechanism of injury. In particular, any indication of pre-existing aseptic loosening around the stem (eg, expressed pain in the anterior thigh during ambulation) is important to note. Furthermore, fevers, chills, draining of the sinus tract, prolonged time required for healing of the wound after the primary procedure, and the need for antibiotic treatment during the initial perioperative period suggests that systemic signs of infection are predisposing factors for the fracture, which can affect future technique of treatment.

Physical examination typically includes a detailed neurovascular and skin evaluation in diagnosing the injury. Identification of scars can help determine the previous technique used during the index procedure. Additionally, findings of the physical examination can be helpful in assessing risk factors of periprosthetic factors, including comorbidities and general health status of the patient.

Results of laboratory analysis should also be obtained during preoperative evaluation of the patient. Despite the described incidence of infection in 11.6% of periprosthetic femur fractures, authors have discouraged the workup routines involving erythrocyte sedimentation rate, C-reactive protein, and white blood cells in patients without clinical findings suspicious of infections.[8]

Routine imaging procedures should include anteroposterior (AP) views of the pelvis and AP and lateral views of the affected femur. Radiographs should be evaluated for fracture characteristics, stem loosening, polyethylene wear of stem, and available bone stock on both the femoral and acetabular sides of the injury. In general, cross sectional advanced imaging may not be necessary during standard workup of periprosthetic femur fractures.

Mortality Rates

Mortality and morbidity rates associated with periprosthetic femur fractures are more similar to those of patients with general hip fractures than those of patients who underwent revision THA. Reported mortality rates relating to periprosthetic hip fractures range from 7% and 18% at 1 year after initial injury,[7] which is greater than noted in patients who underwent primary THA. The New Zealand Registry described 7.3% and 0.9% rates of mortality of patients at 6 months after revision THA for treating periprosthetic femur fractures and aseptic loosening around the stem, respectively.[9] In particular, a high perioperative risk of mortality has been found in patients with periprosthetic femur fractures after undergoing hemiarthroplasty. In a recent study of 79 patients with periprosthetic femur fractures after hemiarthroplasty treated using a standard algorithm, mortality was reported in 11%, 23%, 34%, and 49% of patients at 4 weeks, 3 months, 1 year, and 2 years postoperatively, respectively.[10] These data indicate that careful perioperative management of comorbidities may be essential in treating patients with periprosthetic femur fractures identified after hemiarthroplasty.

Classification and Treatment

Based on findings from imaging procedures, periprosthetic fractures can be categorized using the Vancouver classification system[11] that describes anatomical location of fracture, stability of used stems, and available bone stock. The successfulness of treatment can depend on appropriate classification of the fracture, particularly into types A_G, A_L, B1, B2, B3, and C.

Vancouver Type A Fractures

Vancouver type A fractures are anatomically located in the greater trochanter (Vancouver type A_G) or lesser trochanter (Vancouver type A_L) around a well-fixed femoral stem. In a case series of 24 type A_G fractures treated nonoperatively without weight-bearing restrictions or bracing, the authors reported resolution of pain in most patients, with a nonunion rate of about 50% yet minimal functional impairment.[12] The opposing pulls of the abductors and vastus lateralis of the thigh may prevent further displacement of fractures.

Additionally, the presence of osteolysis should be determined in treating Vancouver type A_G fractures. In a case series of 17 type A_G fractures treated nonoperatively and associated with osteolysis resulting from polyethylene wear of the stem, about 37% of stems remained intact at mean 3-year follow-up, despite healing of the bone in nearly all cases.[13] Although nonoperative methods have been advocated for treating most Vancouver type A_G fractures, the presence of osteolysis may indicate the need for a revision procedure. Other suggested operative indications for revision procedures include intraoperative fractures and largely displaced fractures, suggesting discontinuity of the soft-tissue sleeve located between the abductors and vastus lateralis.[7] Generally, operative methods involve claw plate fixation.

On the other hand, most type A_L fractures are avulsion based, which can be treated nonoperatively. However, it is essential to differentiate between small avulsion fractures of the lesser trochanter caused by contraction of the iliopsoas and avulsion fractures involving notable portions of the medial cortex of the femur. The latter usually become evident by postoperative week 6 and can be more appropriately classified as Vancouver type B2 fractures because of subsequent instability of the stem.[14]

Vancouver Types B1 and C Fractures

Vancouver types B1 and C fractures account for about 40% of periprosthetic femur fractures.[15] Type B1 fractures occur around well-fixed femoral stems, whereas type C fractures occur at the distal end of the femoral stem. Operative treatment of both types with osteosynthesis has been standard; however, numerous authors in Europe have recommended revision THA instead.[15-17] Nonoperative treatment of types B1 and C fractures using traction and bracing methods has resulted in high rates of malunion, symptomatic stem loosening, and postoperative complications of immobility such as deep vein thrombosis and ulcers. Currently, most authors recommend operative treatment of patients who can survive the stress associated with undergoing surgical procedures.[18]

The modern technique used during osteosynthesis is essentially a modification of the technique described in 1978 by Ogden and Rendall.[19] This study described fixation of a lateral plate around the proximal and distal ends of the stem, using cables and bicortical screws, respectively. After many studies reported unsuccessful treatment using a single lateral plate, some authors began to investigate treatment with adjuvant fixation of pins using allograft struts. In a series of 40 types B1 and C fractures treated operatively using cortical onlay allograft struts or allograft struts with a lateral plate, union of the fractured bone was reported in 39 fractures, with greater than 10° malunion noted in four.[20]

A more recently published study described types B1 and C fractures (n = 50) treated with open reduction and internal fixation (ORIF) using biologically friendly techniques such as lateral plates without allograft. Union was reported of all fractures in patients who presented at final follow-up, with less than 5% of malalignment in all cases.[21] Furthermore, a systematic review on 37 papers and 682 fractures compared the postoperative results between ORIF and plate fixation with and without use of allograft struts, respectively. Resulting rates of union were similar between the groups, but the use of allograft struts was associated with higher infection rates and longer time to union than with plate fixation.[5] Subsequently, the currently accepted technique used in osteosynthesis has involved biologically friendly treatment of the fracture, without routine use of allograft struts.[22]

Studies have investigated methods to improve the biomechanical stability of implants used in the original Ogden method for treating Vancouver types B1 and C fractures. The vulnerable area of the fixation technique may be related to the proximal end of the screw. Results of finite element analysis indicated that adding unicortical locking screws to supplement fixation of cables proximally improved the rigidity of the construct, whereas applying cable fixation to bicortical screws distally did not significantly improve the stability of the construct.[23] Bicortical screws placed around the proximal end of the stem have shown optimal fixation, but use of unicortical locking screws were helpful in improving axial stiffness to cable constructs for proximal fixation.[24] Particularly in treating Vancouver type C fractures, level of stress concentration may predispose patients to future periprosthetic fractures after the initial fixation procedure. Proximal fixation should optimally overlap the stem when using a lateral plate to fix Vancouver type C fractures, and stress concentration can be increased maximally, with close proximal fixation to the tip of the stem until overlap occurs.[25]

Although osteosynthesis remains the standard procedure for treating periprosthetic fractures around well-fixed stems in the United States, numerous European authors have advocated for revision THA in this scenario. In a study on 52 patients with periprosthetic femur fractures, the mortality rates at postoperative month 6 were lower in the revision THA group than the ORIF group, including a subgroup analysis of B1 fractures.[16] In a retrospective analysis on 1049 periprosthetic femur fractures and risk factors, use of a well-fixed stem with ORIF rather than revision THA was associated with failure.[15] In contrast, results of multiple case series on ORIF for treating periprosthetic fractures around well-fixed stems have shown high union rates with minimal complications.[20,21] Despite suggested improved results with revision arthroplasty, osteosynthesis remains the standard treatment of periprosthetic femur fractures around well-fixed stems.

Vancouver Types B2 and B3 Fractures

Vancouver type B2 fractures involve loose femoral stems and account for 53% of periprosthetic femur fractures, whereas Vancouver type B3 fractures occur around loose femoral stems with inadequate bone stock and account for 4% of periprosthetic femur fractures.[15] In properly classifying and treating Vancouver types B2 and B3 fractures, identification of stem loosening is essential. In a study on types B2 and B3 fractures treated with use of modular fluted, tapered stems, a total of 98% of fractures healed and 98% of femoral stems were well fixed at follow-up, with instability of stems as the main postoperative complication.[26] Findings of other studies have similarly indicated successful treatment of types B2 and B3 fractures using modular distally fixed stems.[27,28]

Vancouver type B3 fractures with severe bone loss can be treated using allograft prosthetic composite (APC) or proximal femoral replacement (PFR). Published survivorship of APC varies between 70% and 90% at 2 to 15 years postoperatively.[29] Commonly reported complications with APC include infection, allograft resorption, trochanteric escape, and junctional nonunion. In general, APC is performed on young active patients, whereas PFR is indicated for treating patients aged 70 and older. Results of a study on 48 patients with non-neoplastic conditions (ie, type B3 fractures) treated with PFR indicated a 73% survivorship at 5 years postoperatively, with a 30% complication rate and the most common complication being stem instability.[30] Both APC and PFR require high levels of technical skill owing to long operating times, high amount of blood loss, and surgical-related stress experienced by the patient.[29]

Conclusion

Periprosthetic femur fractures after THA and hemiarthroplasty are common challenges for modern-day orthopaedic surgeons. Successful treatment requires careful assessment and management of medical comorbidities owing to high rates of morbidity and mortality in patients with pre-existing conditions. Most of these fractures occur around a loose stem (Vancouver type B2 classification), which can be appropriately treated with revision THA using long, uncemented, porous-coated stems for diaphyseal fixation. Vancouver types B1 and C fractures can be treated using biologically friendly techniques with ORIF, focusing on optimizing proximal fixation using a mixture of cables, bicortical screws, and unicortical locking screws. In general, Vancouver type A fractures may be effectively treated nonoperatively. Surgeons should consider patient comorbidities, fracture type, and level of technical skill required in performing successful procedures for treating periprosthetic fractures of the femur.

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Conflict of Interest

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