11 Periprosthetic Fracture of the Femur After Total Hip Arthroplasty

Khalid Azzam and R. Michael Meneghini

Case Examples

Case 1: An 86-year-old female who had undergone an uncomplicated total hip arthroplasty presented 5 months following her surgery after a ground-level fall with complaints of pain in her hip. X-rays revealed a periprosthetic femur fracture around a subsided femoral component (Fig. 11.1).

Case 2: A 45-year-old male with a history of slipped capital femoral epiphysis of his left hip that was treated with in situ pinning presented with end-stage arthritis of the hip (Fig. 11.2a). He is 6 ft tall and weighs 245 lbs. He had retained hardware from a previous failed attempt at removal. During his total hip arthroplasty, the hip was dislocated with the screw in place. The screw had previously been stripped. The neck cut was made, exposing the distal end of the threaded end of the screw, which was then extracted in a retrograde fashion. The femoral canal was then broached for a flat wedge tapered stem and the final implant was press-fit into the canal. In the recovery room, postoperative X-ray demonstrated a periprosthetic femur fracture at the tip of the femoral component (Fig. 11.2b). This had not been noticed intraoperatively.

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Background

The earliest case report of a periprosthetic femur fracture after total hip arthroplasty (THA), in 1954, was of a female who suffered an intertrochanteric fracture around the stem of a cemented hemiarthroplasty. The fracture was fixed using transfixing bolts and wire loops, and the prosthesis was reinserted [1]. In 1964, Parish and Jones [2] reported nine cases of femur fractures around Austin-Moore and Thompson prostheses. The authors classified the fractures according to the location of the fracture to intertrochanteric, proximal, mid-shaft, and distal fractures. Two years later, Sir John Charnley [3] described a periprosthetic femur fracture around a cemented Thompson prosthesis. She was treated with balanced traction and the fracture healed after 3 months [4].

Incidence

Periprosthetic femoral fractures may occur intraoperatively, or early or late postoperatively following THA. Depending on the femoral fixation

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Fig. 11.1 Vancouver B_2 femoral fracture 5 months following total hip arthroplasty with subsequent stem subsidence

method used, differences in the incidence of intraoperative fractures have been reported. An incidence of 0.1–3.5% has been reported with cemented stems [4, 5]; however, an increase of intraoperative fractures has been reported with the introduction of uncemented stems [4, 6]. Schwartz et al. [7] studied 1318 consecutive uncemented total hip replacement arthroplasties and found 39 intraoperative fractures of the femur (3%), only half of which were diagnosed intraoperatively. A recent study from the Mayo Clinic registry [8] showed an intraoperative fracture incidence of 0.2% in 15,178 primary cemented and 3% in 17,466 uncemented THAs. The 20-year cumulative probability of postoperative periprosthetic femoral fractures was 2.1% after placement of a cemented stem and 7.7% with uncemented stems. In revision surgery, an even higher incidence has been reported. In 1999, Berry [9] reported an intraoperative fracture incidence of 3.6% in cemented and 20.9% in uncemented revision THAs. A review of the Swedish registry showed late femoral periprosthetic fracture to be the third most frequently reported cause for reoperations after THA (9.5% of the reoperations), after aseptic loosening and recurrent dislocation [10].

Etiology and Risk Factors

In a retrospective review of 93 periprosthetic fractures, Beals et al. [11] found that the most common mechanism of late fracture was a ground-level fall (84%). Several potential risk factors for periprosthetic fractures around THA have been studied including primary diagnosis, age, osteolysis, aseptic loosening, revision, and implant design type.

Primary Diagnosis

A matched case-control study of the Finnish registry showed that patients who had fracture as primary diagnosis for arthroplasty had a 4.4 times higher risk of periprosthetic fracture than those operated on for other reasons [12]. Similarly, analysis of 321 periprosthetic fractures reported to the Swedish registry showed that an index diagnosis of hip fracture was significantly more common than an index diagnosis of osteoarthritis or inflammatory arthritis in the fracture group ($p < 0.001$) [10].

Age

Cook et al. [5] examined a cohort of 6458 primary cemented femoral prostheses implanted from 1983 to 1999. Patients older than 70 years had a 2.9 times greater risk of sustaining a subsequent fracture. It is likely that increased age is associated with increased incidence of periprosthetic fractures due to a number of factors including osteoporosis, increased risk of falls, lower body mass index, higher incidence of osteolysis and loose stems, and a higher likelihood of having had a revision surgery [13].

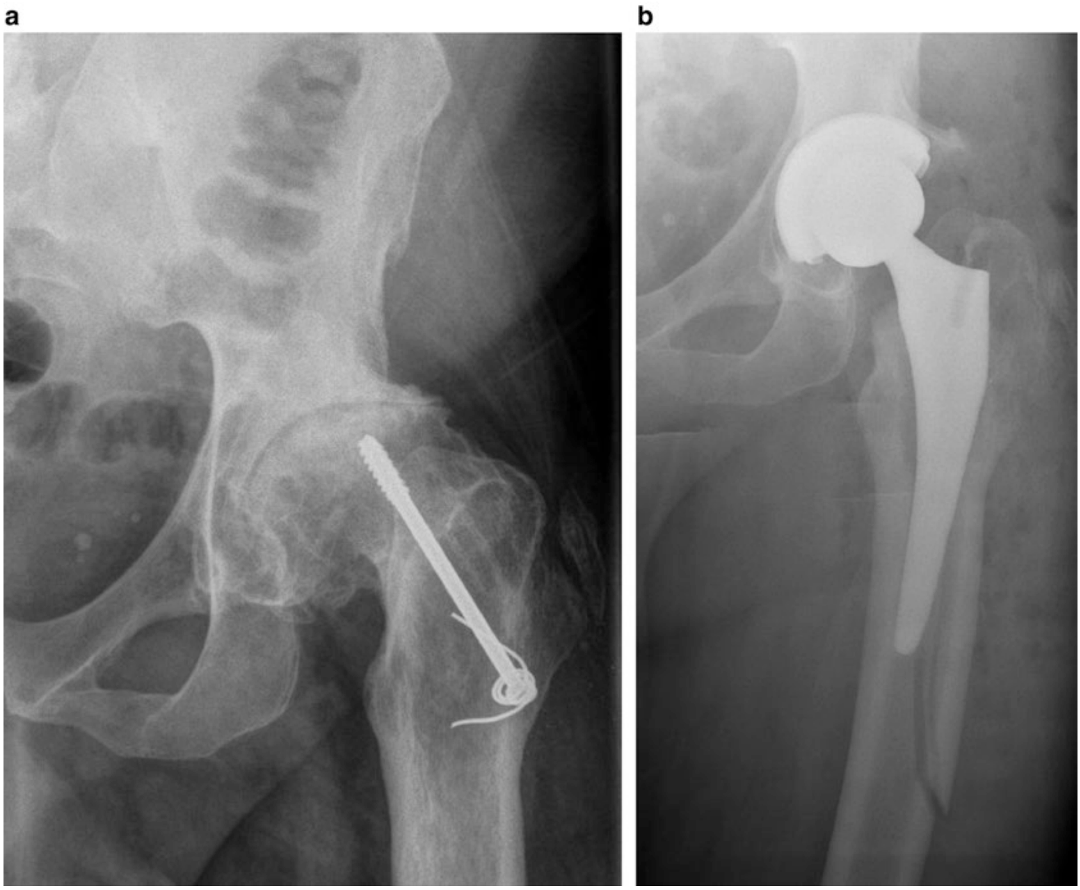

Fig. 11.2 (**a**) Preoperative radiograph demonstrating hip osteoarthritis following slipped capital femoral epiphysis. (**b**) Intraoperative femoral fracture in the diaphyseal region discovered postoperatively

Osteolysis

Late periprosthetic fracture associated with osteolysis has been recognized as a growing problem in arthroplasty [14]. The greater trochanter is a common area for osteolytic fractures because it is a large cancellous bone surface in proximity to the source of particle generation. The high stress imparted by the abductors in combination with the frequency of osteolytic lesions not infrequently leads to fracture in this area [14].

Aseptic Loosening

Loose implants have been demonstrated to be risk factors for periprosthetic fracture in several studies [10, 15–17]. In a review of 321 periprosthetic fractures reported to the Swedish National Hip Arthroplasty Register, Lindahl et al. [10] found that a high number of patients had a loose stem at the time of the fracture (66% in the primary THA group and 51% in the revision THA).

Revision Surgery

Revision total hip arthroplasty is frequently associated with bone loss and challenging implant fixation. Wear debris and resultant osteolysis can reduce available bone stock for fixation at the time of revision [13]. In a study of 215 Medicare beneficiaries who had periprosthetic femoral fracture between 2006 and 2008, a greater risk of periprosthetic fracture was associated with having had a revision total hip replacement [18]. In a study of 64 patients who sustained an intraoperative fracture of the femur during revision hip arthroplasty with a diaphyseal fitting cementless stem, risk factors associated with an intraoperative fracture were a substantial degree of preoperative bone loss, a low femoral cortex-to-canal ratio, under-reaming of the cortex, and use of a large-diameter stem [19].

Implant Design Type

Little is known about how the design features of cementless implants affect a patient's risk for subsequent periprosthetic fracture. In a study of 111,899 uncemented femoral stems reported to the Nordic Arthroplasty Register from 1995 to 2009, the authors demonstrated an increased risk of fractures with the ABG II stem (anatomic design) and a decreased risk for the Corail stem (wedge design). Given that a wedge-shaped stem could be expected to more frequently act as a stress riser with its comparatively sharp corners compared with a rounded design, the authors concluded that these results were difficult to interpret [6]. Another study of 3964 primary THAs in which an alumina grit-blasted, proximally hydroxyapatite-coated femoral component with an exaggerated proximal taper angle was compared to five cementless, proximally fixed stems of different design showed an increased risk of early and late postoperative femoral fractures in hips implanted with that particular stem design. The stem was subsequently discontinued by the manufacturer [20]. In cemented stems, some studies have shown increased risk of fracture with a polished stem designed to subside in the cement mantle [6, 12, 21]. An inadequate cement mantle, with implant contact with the inner and distal femoral cortex, has been correlated with long-term loosening, femoral osteolysis, and subsequent risk for fracture [21].

Evaluation

Since the fixation status of the implant is a critical aspect to the treatment algorithm, it is essential that the examiner elicit any signs and symptoms that may suggest implant loosening prior to the injury, such as start-up thigh pain. The injured limb's neurovascular status and soft-tissue condition should be carefully documented. Preoperative planning should include identification of previous surgical scars, review of previous operative reports, and appropriate workup for infection in patients with previously symptomatic implants. Synovial fluid WBC count and neutrophil percentage are the best tests for diagnosing prosthetic joint infection and have similar cutoff values as when used for detecting infection in patients without a periprosthetic fracture [22]. High-quality standard anteroposterior and lateral radiographs of the affected hip and femur as well as any previous radiographs, if available, should be reviewed in an attempt to determine the stability and fixation status of the implant if possible [23].

Classification

The Vancouver Classification (Table 11.1) is currently the most widely used and accepted and is based on fracture location with subtypes

Table 11.1 Vancouver classification of periprosthetic femur fractures after total hip arthroplasty

Vancouver classification of periprosthetic femur fractures		
Type	Fracture location	Subtype
A	Trochanteric region	A_G: fractures that involve the *greater* trochanter
		A_L: fractures that involve the *lesser* trochanter
B	Around the stem of the femoral component, or extend slightly distal to it	B_1: the implant is stable
		B_2: the implant is loose and the bone stock around the femoral component is adequate
		B_3: the implant is loose and the bone stock around it is inadequate to support traditional femoral implants
C	Well distal to the stem	

in the B-type fractures based on implant fixation status and bone loss [24].

Prevention

Prevention of periprosthetic femur fractures around total hip arthroplasty begins with careful preoperative planning and identifying patients who are at risk of such a complication. Attention to preventing and identifying small intraoperative fractures is critical so that they can be addressed intraoperatively. Prevention of late periprosthetic femoral fractures is best accomplished through routine clinical and radiographic follow-up [13]. Regular monitoring of patients allows for early detection of osteolysis and aseptic loosening, and thus facilitates timely revision surgery.

In a review by Tsiridis et al. [16], several preventive measures for periprosthetic femur fractures were identified. Preoperatively, attention to careful component templating and identifying at-risk patients is of paramount importance. Intraoperatively, fractures could be prevented by careful dislocation of the hip and by following proper technique of femoral canal preparation and careful insertion of the final prosthesis.

In revision settings, it is important to obtain adequate surgical exposure, which may involve various peri-trochanteric osteotomies to aid with prosthetic alignment and component or cement removal. Both careful reaming and avoidance of eccentric or varus directions when using the reamers are important and may be facilitated by judicious use of radiographs during femoral preparation and implant insertion. It may be of value to strengthen the femur prophylactically by using cerclage wires prior to femoral preparation and implant insertion, and it is the authors' practice to place a prophylactic cerclage wire just distal to the osteotomy site if an extended trochanteric osteotomy is used to prevent iatrogenic fracture propagation. If a fracture has already occurred, cerclage wiring can be used to prevent it propagating further and should be placed sufficiently past the most distal extent of the fracture to protect the intact femoral canal. Cement removal is most safely achieved by splitting it radially and at several levels or by using ultrasound. Cortical defects and osteolytic lesions should be bypassed when possible. Cortical strut grafts may be used prophylactically to reinforce cortical defects and other stress risers. Postoperatively, good-quality anteroposterior and lateral radiographs of the entire length of prosthesis should be obtained before weight bearing to exclude unrecognized fractures.

Treatment of Late Periprosthetic Femur Fractures

Treatment of periprosthetic fractures after total hip arthroplasty is summarized in Table 11.2.

Type A Fractures

Type A_G fractures are stable when minimally displaced because they are securely positioned

Table 11.2 Treatment of femur fractures after total hip arthroplasty

Type A (trochanteric)	
• AG	• Trochanteric plate fixation for large, markedly displaced fractures
	• Nonoperative treatment for late, osteolysis-related fractures
• AL	Nonoperative treatment
Type B (stem region or slightly distal)	
• B1	Confirm implant stability, reduction, and internal fixation of displaced fractures using a locked plate-cable system
• B2	Stem revision, bypass with a long-stem prosthesis by minimum of two cortical diameters, supplemental cerclage cables as needed
• B3	• Reconstruction with a long, fluted modular stem that engages any remaining isthmus, cable fixation of the fracture pieces around the proximal body of the implant
	• Allograft-prosthetic composite versus proximal femoral replacement in cases where fluted stem fixation is not possible
Type C (well distal to the stem)	Fixation according to the fracture type, making sure that the fixation construct overlaps the tip of the femoral stem to avoid leaving weak segments of bone

Fig. 11.3 Extensive trochanteric osteolysis and fracture around a well-fixed cylindrical stem

by the tendons of the vastus lateralis and the abductors, which prevent further displacement and proximal migration. This fracture is usually related to wear-debris osteolysis of the greater trochanter (Fig. 11.3) [25]. Nonoperative treatment for several months to allow bone healing or stable fibrous union before revision for osteolysis is typically recommended. A hip abduction brace may help reduce pain while the fracture is healing [14].

If the greater trochanteric fragment is large and markedly displaced, and the remaining bone is satisfactory to gain fixation, then early revision to restore abductor mechanism continuity with internal fixation of the greater trochanter to its bed or to an advanced position may be considered [14]. Type A_L fractures as an isolated injury can usually be ignored unless there is a distal extension involving the medial cortex that has destabilized the fixation status of the femoral stem [25].

Type B Fractures

Nonoperative treatment has been practiced in the past [3, 26], but because of its high morbidity, surgical treatment of these fractures has been established as the preferred treatment. Internal fixation may be used either alone or in combination with stem revision. The stability of the original implant, amount of bone loss, and configuration of the fracture itself are the basic factors that influence the decision-making process. Lindahl et al. [27] found that a major risk of failure in the treatment of these fractures is misinterpretation of the stability of the stem and misclassifying type B_2 fractures as type B_1, resulting in treatment with plate fixation without revision of the stem. This fact necessitates a careful assessment of the fixation status of the femoral stem in every type B periprosthetic femur fracture with additional confirmation intraoperatively.

Type B_1 Fractures

Due to the femoral component being well fixed, the principal strategy of type B_1 fractures is internal fixation of the periprosthetic bone without femoral revision. Different fixation techniques were tested and compared in an in vitro study by Schmotzer et al. [28]. The authors compared allograft struts with wire cerclage (18-gauge Vitallium, Howmedica), allograft struts with multifilament cable cerclage (Dall-Miles, 2 mm stainless steel, Howmedica), bypassing the fracture with a long stem (PCA, Howmedica), long stem with allograft struts and cerclage, plate (Synthes, Paoli, PA) with cables proximally and bicortical screws distally, and plate with unicortical screws (4.5 mm, Synthes) proximally and bicortical screws distally. The authors concluded that cables were significantly stronger and more appropriate than standard cerclage wiring and that compression plating with combined proximal cables and unicortical screws should be preferred over proximal wire fixation alone [28].

Cable-Plate System

In an early effort to provide rigid fixation around the femoral construct of a THA, Berman and Zamarin [29] introduced the Dall-Miles plate-cable system (Stryker Howmedica, Mahwah, NJ) in a case report in 1993. The system included 1.6 and 2.0 mm braided Vitallium alloy cables, small and medium sleeves, medium and large grips, and plates of varying length. Cable tensioners were used to tighten the cables. It also allowed unicortical screw fixation with cable augmentation proximal to the fracture, in addition to bicortical screws distal to the fracture.

Four years later, Haddad et al. [30] documented their use in a small series of four periprosthetic fractures that all had excellent clinical outcomes. The study of Sandhu et al. [31] reported the outcome of 20 fractures treated with this system. All of the fractures united with no fixation failures over a postoperative period of 1–4 years. However, two type B_1 fractures later collapsed into varus, and both of these cases were treated with a plate fixed only with cables. Based on these results, the authors recommended that fixation of the plate with cables alone should be avoided because of the torsional instability of the construct [32]. Similarly, Dennis et al. [33] in a biomechanical study showed that plate constructs with proximal unicortical screws and distal bicortical screws or with proximal unicortical screws, proximal cables, and distal bicortical screws were significantly more stable in axial compression, lateral bending, and torsional loading than a plate with cables alone, plate with proximal cables and distal bicortical screws, or two allograft cortical strut grafts with cables. Tsiridis and colleagues [34] reported failure by fracture of the Dall-Miles plate in two out of three B1 fractures. The plates were stabilized with cables proximally and bicortical screws distally below the tip of the femoral component.

Compression Plating

The first description of compression plating of periprosthetic femoral fractures was by French authors [35]. In 1992, Serocki et al. [36] treated ten periprosthetic femur fractures with 4.5 mm broad dynamic compression plates. The authors identified one limitation of these plates, which only allowed 7° and 25° of screw angulation when trying to avoid the stem. A prospective study of plate fixation of Vancouver B_1 fracture types was published in 2005 by Ricci et al. [37] who evaluated 37 cases. Indirect reduction techniques were applied in all cases, sometimes preserving a soft-tissue bridge over the fracture site to minimize the operative trauma to the soft-tissue envelope, and reduction was achieved using fluoroscopy and traction. Fixation was accomplished with a standard 4.5 mm broad DCP in 27 of the 37 cases, which was secured on the bone via unicortical or bicortical screws and cables. No strut allografts or cancellous bone grafts were used to augment the osteosynthesis and all fractures united at an average of 3 months. The authors emphasized that the plate must be of sufficient length to bypass the implant by a minimum of six screws and that soft-tissue dissection should be minimized to preserve blood supply and facilitate osteosynthesis.

Locking Plates

Locking plates carry the advantage of both axial and angular stability because the screw heads are locked to the plate body by a threaded interface. They also provide the option of preservation of fracture-site vascular supply via use of minimally invasive insertion techniques [38]. Fulkerson et al. [38] performed a biomechanical comparison of standard Ogden plate-cable systems with the locking plates for fixation of fractures at the tip of well-fixed cemented stems (B_1 fractures). The locked plating constructs used a 4.5 mm broad locking compression plate (LCP) that was secured to the cadaveric femur, with three unicortical locking screws proximally and three bicortical distally. The Ogden constructs consisted of stainless steel plates that were fixed via three 1.8 mm steel cables in the proximal fragment and three non-locked bicortical screws distally. The locked plate was stiffer than the Ogden plate in axial compression and torsional loading, but not in lateral bending. The two constructs also showed different modes of failure during torsional loading. The LCP failed by lateral cortex fracture through the proximal screw holes, and the Ogden cable-plate system failed through the proximal cable cutting through the lesser trochanter. Locked plate construct cement mantles exhibited no evidence of cracks or gross loosening at the cement-screw interface.

Cable-ready locked plates with screw holes that allow combination of polyaxial locking and non-locking screw fixation have gained popularity in fixation of periprosthetic fractures of the femur. These plates allow insertion with less invasive techniques that allow preservation of soft-tissue attachments. Locked screws allow better fixation in osteoporotic bone, especially when using unicortical screws in the proximal fracture segment. Non-locking screws have the advantage of being angled to gain fixation in bone anterior and posterior to the femoral stem. They also allow compression across transverse or oblique simple fracture patterns. Cables augment fixation in the proximal segment and allow addition of strut cortical grafts to enhance stability and provide a mechanical and potential biological advantage in osteoporotic bone. Despite all these theoretical advantages, Dehghan et al. [39] in a recent systematic review of the literature showed that locking plates had a significantly higher rate of nonunion (3% vs. 9% $P = 0.02$) and a trend toward a higher rate of hardware failure (2% vs. 7%; $p = 0.07$) compared with cable-plate systems. The authors cited suboptimal surgical technique (such as inadequate fracture reduction), overreliance on the locking plate to gain stability, and use of an excessively stiff construct to bypass the fracture area as potential reasons for the higher nonunion rate compared to conventional unlocked plates.

Strut Grafts

In a retrospective review from 4 centers, 40 patients with a fracture around a well-fixed femoral stem were treated with cortical onlay strut allografts without revision of the femoral component [40]. Nineteen patients were treated with cortical onlay strut allografts alone, and 21 were managed with a plate and one or two cortical struts. Thirty-nine (98%) of the 40 fractures united, and strut-to-host bone union was typically seen within the first year. There were four malunions, all of which had <10° of malalignment, and one deep infection. There was no evidence of femoral loosening in any patient. The authors concluded that cortical onlay strut allografts act as biological bone plates, serving both a mechanical and a biological function and that their use, either alone or in conjunction with a plate, led to a very high rate of fracture union. Despite the lack of a control arm in which only plates are used for fixation, the authors suggested that cortical strut grafts should be used routinely to augment fixation and healing of a periprosthetic femoral fracture. They explained that healing of the strut graft to the host bone involves formation of a zone of highly vascularized mesenchymal tissue. Osteoclasts subsequently create cutting cones in the graft, which is then invaded by vascular buds. The graft remodels and is at its weakest between 4 and 6 months and therefore is vulnerable to mechanical failure unless the fracture has already healed [41].

Disadvantages of strut allografts are increased cost, potential to transmit disease, and that the host femur must be extensively exposed to place the struts which may heavily disrupt the blood supply that is so critical to healing. On the other hand, strut grafts have several advantages. The modulus of elasticity of the struts is similar to that of the host bone and, thus, they are less likely to cause stress shielding. The struts unite with the host bone and eventually make the bone stronger, in addition to stimulating healing of the fracture [42]. The surgeon must therefore weigh the proposed benefit from the additional support provided to an underlying osteoporotic native bone by strut grafts as it heals against the risk of greater dissection necessary to apply them [25].

In an attempt to define more specific criteria for the use of strut grafts, Corten et al. [43] proposed a surgical algorithm that resulted in union of 29 out of 30 periprosthetic fractures treated at their center. In addition to maintaining a high index of suspicion for stem loosening and for testing implant stability intraoperatively if there is any doubt, their algorithm called for the use of locked plates without strut grafting only in those fractures where the medial cortex was not comminuted and could be anatomically reduced. The authors called for refinement of the current treatment algorithm that is based on the Vancouver classification, especially with regard to treating B1 fractures in order to define the most appropriate and biomechanically sound fixation option in individual situations. Buttaro et al. [44] recommended caution when using locked plates alone in treatment of type B_1 fractures based on their results of three plate fractures and three plate pullouts in a series of 14 fractures. All of the failures in their series except one were observed in patients in whom a cortical strut allograft had not been used. In a review of 16 femoral fractures around well-fixed total hip implants, Wood et al. [45] recommended using cortical struts in cases of failed hardware and revision fixation. It appears that the issue of whether lateral plates alone provide enough stability for these fractures, or do strut grafts need to be added, warrants further investigation. We do not use strut grafts routinely in the fixation of periprosthetic fractures, except in cases of severe osteopenia and after failed previous locked plate fixation.

Type B_2 Fractures

When the stability of the implant is questionable, it must be tested intraoperatively. Pike et al. [25] suggested that if the distal aspect of the stem is exposed at the fracture site, it may be tested for instability by generation of shear force along the longitudinal axis between the implant and bone or cement proximally. They recommended using a pointed reduction forceps on the femur and a Kocher forceps grasping the stem tip. If this is not possible, a formal arthrotomy is necessary to gain adequate exposure to exclude stem loosening.

When the femoral component is loose, extramedullary fixation alone has been shown to yield poor results. It is recommended that the stem be revised to a longer stem to bypass the fracture site by at least two cortical diameters when using a fully porous stem. Based on the results of an in vitro study, Schmotzer et al. [28] postulated that newer long-stem revision prostheses that provide distal fixation (flutes or porous coating) likely improve the stability across the fracture site even if no extramedullary support, such as a plate or strut graft, is used. O'Shea et al. [46] treated 22 fractures with a fully porous coated stem (Solution, DePuy, Warsaw, IN) and supplemental cerclage wires with or without a strut graft. Of the 22 patients, 17 had a satisfactory outcome with a Harris Hip Score >80 while 4 patients had subsidence of their stems. One patient developed a deep infection and was revised to tumor prosthesis. Ko et al. [47] treated 12 patients with Vancouver B2 fractures with a conical fluted stem. At an average follow-up of 56.5 months, all 12 reconstructions showed a stable prosthesis and solid fracture union. Two patients had poor outcomes because of significant leg shortening in one patient and a new fracture in the other.

Type B_3 Fractures

Severe proximal femoral bone loss makes it even more challenging to achieve good femoral component and fracture fixation as is seen in a Vancouver B3 periprosthetic fracture (Fig. 11.4). Options for treatment of such challenging fractures include

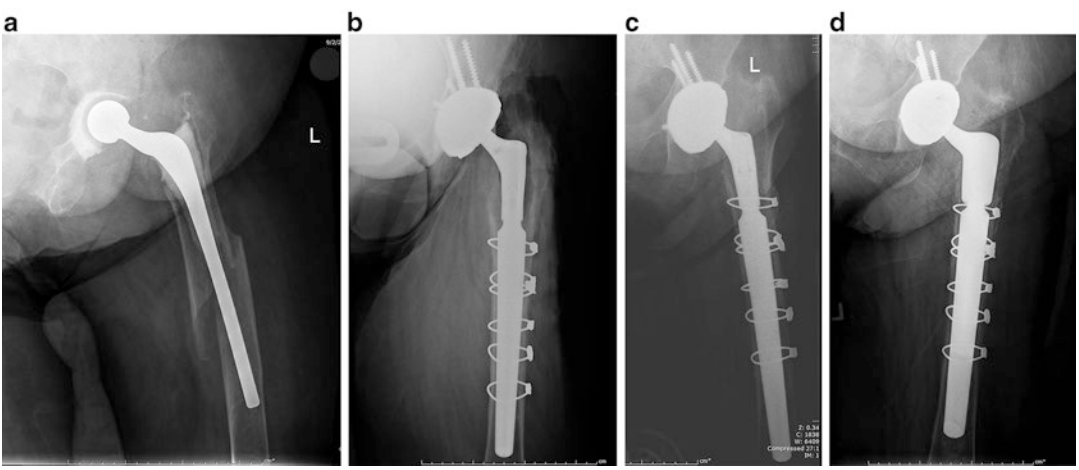

Fig. 11.4 (**a**) Vancouver B_3 fracture around a temporary hip spacer. (**b**) Patient underwent a revision with modular fluted tapered stem that (**c**) later subsided and (**d**) was revised to a larger diameter modular fluted tapered stem

long cylindrical or fluted stems, with or without cortical strut grafting, allograft-prosthetic composite, or proximal femoral replacement. The optimal method of reconstruction depends on the patient's physiologic demands, fracture extent and location, and degree and severity of bone loss.

Long modular fluted tapered uncemented stems with retention of the proximal femur have been successfully used by Berry et al. [48] who treated eight patients with a modular fluted tapered grit-blasted titanium stem. Seven patients were available for follow-up. The revision stem was potted distally and the fractured fragments were pulled together around the stem using cerclage cables while preserving their muscular envelope. At a mean follow-up of 1.5 years, he found that all implants were stable and all fractures had healed. Munro et al. [49] treated 55 patients with Vancouver B_2 and B_3 fractures with a modular titanium fluted stem. Cortical onlay allografts were used in 14 of the B_3 fractures. They reported one nonunion, stem loosening in one patient, and infection in another patient. They did however notice a 24% rate of subsidence on radiographic evaluation.

Springer et al. [50] reported on a series of 35 Vancouver type B3 fractures treated with revision arthroplasty. The authors recommended the use of allograft-prosthesis composites or tumor prostheses in patients with severe damage to the proximal part of the femur, and uncemented, fluted, tapered stems that gain axial and rotational stability distal to the fracture in select cases. In a retrospective case series of 44 Vancouver B2 (25 patients) and B3 (19 patients) periprosthetic femur fractures treated with fluted, modular, tapered stems at the same institution, the authors reported good radiographic healing and stable femoral stems in 43 out of 44 cases (98%) at an average follow-up of 4.5 years. Five patients (11%) had recurrent instability and two patients developed deep infection [51].

In femoral fractures in which bone loss extends past the femoral diaphysis, and the geometry of the remaining femur will not support an uncemented stem, reconstruction with tumor prosthesis or an allograft is indicated. Blackley et al. [52] reported their experience with 63 total hip arthroplasties in 60 consecutive patients revised with a proximal femoral allograft-prosthesis construct. The success rate, defined as a postoperative increase in the Harris Hip Score of greater than 20 points, a stable implant, and no need for additional surgery related to the allograft, was 77% (37 of 48 hips). They used a transtrochanteric approach and a step-cut osteotomy of the femur to stabilize the host-graft junction. Stems were cemented into the allograft and press-fit into the distal femur. Haddad et al. [53] reported on 40 proximal allograft reconstructions in which the stem was cemented into the allograft and the host femur. There were four early revisions (10%) for infection and allograft nonunion, junctional nonunion in three patients (8%), instability in four (10%), and trochanteric nonunion in 18 patients (46%). Despite the high revision rate (13 out of 40 patients), the authors recommended continued use of structural allografts for failed total hip replacements with loss of proximal femoral bone.

Klein et al. [54] reported on a series of 21 patients with B_3 fractures treated with a proximal femoral replacement. Intraoperative hip instability with adequately positioned components was addressed with constrained liners. At the latest follow-up, the average Harris Hip Score was 71 points (range 56–90). All stems were stable at the latest follow-up (mean, 3.2 years). Dislocation occurred in two hips. The authors concluded that proximal femoral replacement for the treatment of these difficult fractures is a viable option for low-demand patients [54]. Lessons learned from this experience suggest that if an allograft prosthetic composite or a proximal femoral replacement is used, the risk of instability is high and the surgeon should thus consider the use of a constrained liner or a dual-mobility bearing.

One technical pearl that may be helpful to the surgeon is the liberal use of an extended trochanteric osteotomy (ETO) in these challenging cases [55]. The ETO is made down to the fracture site, and the loose stem is more easily removed. A prophylactic cerclage wire is then placed distal to the fracture site to protect the intact femoral diaphysis. In general we have found that a modular tapered stem is useful in these scenarios as the isthmic segment for distal fixation is frequently short. The distal intact diaphysis is reamed for the distal segment of the stem, which is then impacted until axial stability is obtained. The modular proximal bodies are then used to recreate leg length, and once engaged in the proper version, the proximal fragments are cabled around the revision stem, taking care to respect the blood supply. This technique facilitates exposure as well as preparation and implantation of the diaphyseal engaging stem under direct visualization.

Type C Fractures

This fracture pattern is characterized by being well distal to the implant and is treated based on the existing diaphyseal femur fracture algorithms except that intramedullary fixation is not viable due to the presence of the femoral stem. In addition, the presence of the femoral stem typically necessitates bypassing the tip of the existing femoral stem proximally. A study of 17 patients with type C periprosthetic femur fractures treated with internal fixation using a locking compression plate (LCP) bridging the implant in place showed fracture union in all cases. Less invasive surgery was performed on 15 patients and open surgery at the fracture site in two cases. They reported one bending-type mechanical complication of the plate [56]. Once again it is important to extend the span of the fixation plate past the tip of the stem so as to avoid leaving a segment of weak bone between the stress risers of the stem tip and proximal end of the plate [25].

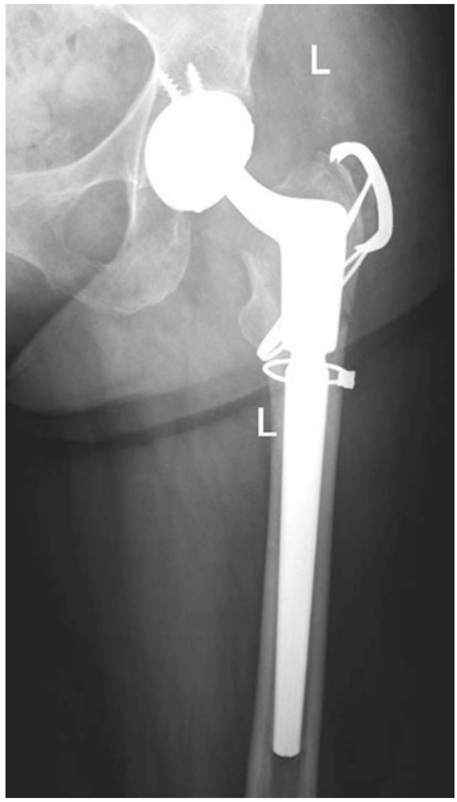

Fig. 11.5 Vancouver B_2 femoral fracture treated with cerclage wire fixation, trochanteric claw plate, and revision to a modular tapered stem

Case Solution

Case 1: The fracture was classified as Vancouver B_2 fracture (i.e., loose stem with adequate bone stock). Intraoperatively, the femoral stem was noted to be subsided deeply into the femur and the fracture was identified running from the medial calcar through the lesser trochanter distally on the anterior aspect. The femoral component was removed easily and two cerclage cables were passed around the proximal femur, one proximal and one distal to the lesser trochanter. The femur was then revised with a diaphyseal-engaging, modular tapered stem. During trial reduction, an audible crack was heard and it was noted that there was a trochanteric fracture at the site of the proximal cable. This was reduced anatomically and fixed with a trochanteric claw (Fig. 11.5). The fracture went on to heal and the stem was stable at 6 months postoperatively.

Case 2: The fracture was deemed unstable and the patient was taken back to the operating room for a femoral component revision. Two Dall-Miles cables were placed around the fracture and snugged primarily but not to the terminal tightness. The clamps were left on. The hip was then dislocated and the femoral component removed. The Dall-Miles cables were tightened further leading to an anatomic reduction of the fracture

Fig. 11.6 The patient was taken back to the operating room and the femoral component was revised to a diaphyseal-engaging stem extending at least two cortical diameters past the distal extent of the fracture

fragments. They were clamped appropriately. The femur was then revised with a diaphyseal-engaging, modular tapered stem extending at least two cortical diameters past the distal extent of the fracture (Fig. 11.6). The fracture went on to heal and the stem was stable at 6 months postoperatively.

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