Review Article

Principles of Treatment for Periprosthetic Femoral Shaft Fractures Around Well-fixed Total Hip Arthroplasty

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Abstract

Postoperative periprosthetic femoral fractures around the stem of a total hip arthroplasty are increasing in frequency. To obtain optimal results, full appreciation of the clinical evaluation, classification, and modern management principles and techniques is required. Although periprosthetic femoral fracture associated with a loose stem requires complex revision arthroplasty, fractures associated with a stable femoral stem can be managed effectively with osteosynthesis principles familiar to most orthopaedic surgeons. Femoral fracture around a stable femoral stem is classified as a Vancouver type B1 fracture. The preferred treatment consists of internal fixation, following open or indirect reduction. Emerging techniques, such as percutaneous plating and the use of locking plates, have been used with increasing frequency. Preliminary results of these techniques are promising; however, further prospective comparative studies are required.

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Total hip arthroplasty (THA) is a highly effective treatment with a relatively low probability of complications. One potential complication of THA is periprosthetic fracture, the prevalence of which is increasing.[1-5] The reported incidence varies between 0.1% and 18%.[1,5-9] The Mayo Clinic Joint Replacement Database reported the largest series, which identified an incidence of 1% (238 of 23,980) in primary hip arthroplasties and 4% (252 of 6,349) in revision hip arthroplasties.[1] The large range in reported incidence is directly related to the growing population living with THAs and the variable follow-up period under study.

As periprosthetic fractures around THAs are encountered with greater frequency, accurate classification and subsequent treatment decisions for these fractures will be required by a greater breadth of orthopaedic surgeons rather than only those familiar with complex revision arthroplasty techniques. Emerging osteosynthesis techniques familiar to most orthopaedic surgeons are increasingly in use and appear to be effective in the management of fractures about the well-fixed femoral stem, the so-called Vancouver B1 fracture.

Periprosthetic fractures can be broadly differentiated on the basis of intraoperative or postoperative fracture and by either acetabular or femoral involvement. Accurately distinguishing fractures associated with well-fixed stems (ie, B1) from those associated with loose stems (ie, B2, B3) is critical in forming the appropriate management plan. Failure to identify a loose stem is likely to lead to treatment failure if an osteosynthesis technique rather than complex revision hip arthroplasty is performed. The precise identification of postoperative femoral Vancouver type B1 fractures is an important step in fracture management.[10,11]

Risk Factors and Etiology

Several risk factors have been associated with periprosthetic femur fractures. Patient factors include the increasing number of persons undergoing THA,[12] in particular the number of elderly patients at risk for low-energy falls,[1] and young patients with hip implants who participate in activities subject to high-energy trauma.[1] Surgical technique can also affect the potential for periprosthetic femur fracture. Revision arthroplasty techniques that transfer energy to the tip of the implant stem, such as impaction allograft and cementless press-fit stems, may also predispose the patient to periprosthetic fracture.[12-14]

Several patient characteristics may be associated with an increased risk of fracture. Female sex and more advanced age have been named as independent risk factors;[15] however, these factors may be confounded by osteoporosis. Some comorbidities, particularly inflammatory arthropathies, have been suggested to be risk factors but may be compounded by osteopenia.[3,4] Altered bone morphology or deformity, such as that seen with Paget disease,[14] may also increase the risk of fracture.

Clinical Evaluation

History and Physical Examination

Most periprosthetic femur fractures are caused by a low-energy mechanism, usually a fall from standing height.[6,16] High-energy mechanisms account for <10% of reported cases.[17] Premorbid functional status, as well as any symptoms related to the affected hip or thigh that may be suggestive of loosening before the injury, must be elicited. Particular features that may indicate a loose femoral stem include pain focused in the thigh and start-up pain, which is pain experienced with initiation of ambulation on rising from a chair.

Medical records are helpful in establishing preexisting pain and limb-length discrepancy. Identifying the surgical approach used and confirming which implants are currently in situ, including the bearing surface used, facilitate preoperative planning. A complete medical history is also obtained. A history of delayed wound healing, prolonged drainage, or systemic symptoms of infection is significant. A suspicion of infection or of loose stem before fracture warrants further investigation.

Following a general medical examination, comprehensive assessment of the injured extremity is important, although the process is usually limited by pain. The general condition of the skin and the location of previous scars should be documented. Examination of the knee, assessment of leg lengths, and establishing the neurovascular status of the limb are important.

Imaging

Standard AP and lateral radiographs of the affected extremity and pelvis should be obtained. It is important that the full length of the femur be imaged and the radiographs scrutinized to fully appreciate the entire extent of the fracture, to assess the THA components for signs of loosening, and to evaluate the available bone stock. This information allows for determination of the Vancouver classification of the fracture.[10,11] Routine use of advanced imaging, such as ultrasonography, CT, and MRI, is not warranted.

In addition to the femur, the acetabulum should be assessed. Evidence of polyethylene wear, osteolysis, the acetabular shell position, and possible loosening of the acetabular shell should be documented and considered in the management plan. When revision of the acetabulum seems necessary, referral to a surgeon experienced in revision arthroplasty of the hip is advisable.

Excluding Infection

The usual considerations and investigations for excluding occult infection may be complicated in the setting of a fracture. In the absence of a fracture, the erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) level are sensitive indicators of occult infection.[18,19] These markers are not reliable in the setting of a periprosthetic fracture and, therefore, are of limited value. Chevillotte et al[20] found a false-positive rate for

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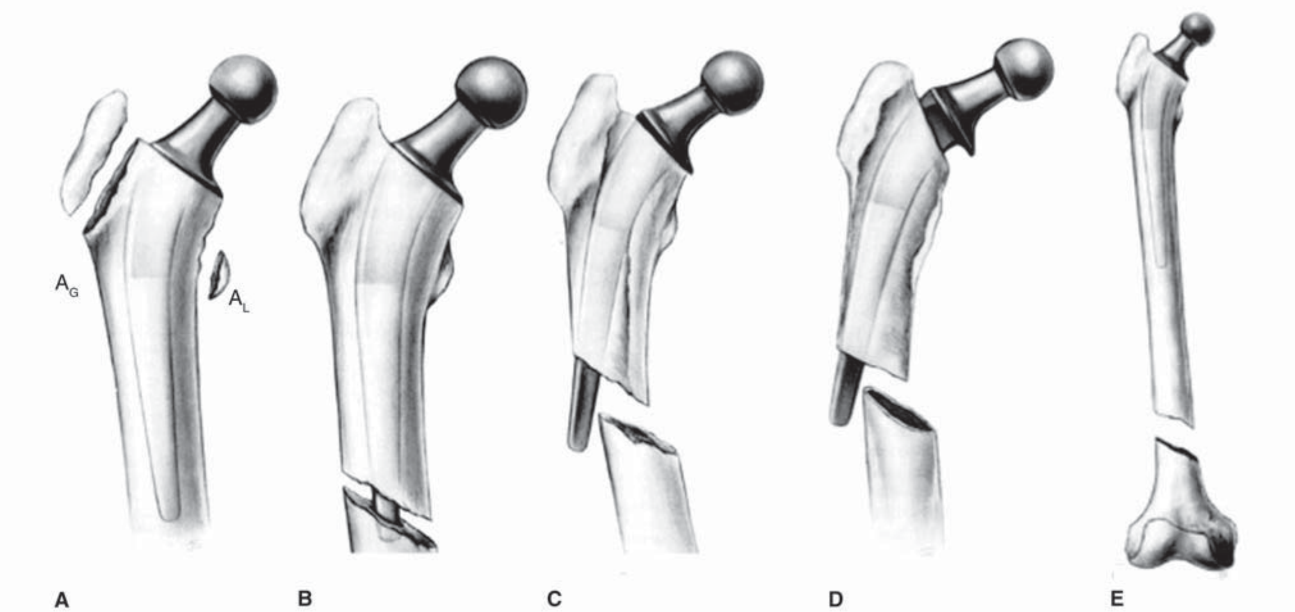
Figure 1



Vancouver classification of postoperative periprosthetic hip fractures. **A,** Type A: trochanteric fracture involving the greater trochanter (type A_G) or lesser trochanter (type A_L). Type B: diaphyseal fracture at the level of or just distal to the implant. **B,** Type B1 fractures are characterized by a stable implant. **C,** Type B2 fractures are associated with a loose implant and adequate bone stock. **D,** Type B3 fractures have a loose implant with inadequate bone stock. **E,** Type C: diaphyseal fracture well distal to the tip of the implant. (Adapted with permission from Garbuz DS, Masri BA, Duncan CP: Fractures of the femur following total joint arthroplasty, in Steinberg ME, Garino JP, eds: *Revision Total Hip Arthroplasty*. Philadelphia, PA, Lippincott Williams & Wilkins, 1999, p 497.)

infection of 43% for CRP level and 31% for ESR in 204 periprosthetic hip fracture patients. When a thorough history, examination, and analysis of radiographs confirms a well-functioning, stable THA without features suggestive of infection, we proceed with surgical fixation without further delay and send intraoperative frozen section only when intraoperative findings are suspicious for infection, which is rare. Tissue for culture is sent routinely in all revision settings with in situ hardware.

Suspicion of occult infection raised in the history is investigated with image-guided aspiration for Gram stain and culture, which may delay definitive treatment for up to 5 days. At the time of surgery, intraoperative tissue samples sent for frozen pathology section can also aid in excluding infection. Infection is defined as >5 neutrophils observed per high-powered field.[19] When infection is encountered, appropriate treatment should be instituted in parallel with management of the fracture.

Vancouver Classification

Accurate classification of periprosthetic femur fractures directs treatment. The Vancouver classification was developed on the basis of the three most relevant features: fracture location, stem stability, and the quality of the remaining bone stock[10,11] (Figure 1). Subsequent investigation has demonstrated its validity and reliability.[21] The classification divides the femur into three anatomic zones: A, trochanteric region; B, diaphysis, including or just distal to the tip of the implant; C, diaphysis well distal to the tip of the implant.

Type A

Type A is subclassified as A_G, for fractures of the greater trochanter, and A_L, for fractures of the lesser trochanter. Type A_G is stable when it is minimally displaced because it is held in place by the digastric composite tendons of the vasti and glutei. This fracture is usually related to wear-debris osteolysis of the greater trochanter. Type A_L as an isolated injury can usually be ignored unless there is a distal extension involving the medial cortex that has destabilized the stem.

Type B

Type B fractures are subclassified based on the stability of the femoral component and the available bone stock. Type B1 fractures are characterized by a stable implant. In both types B2 and B3, the stem is loose.

Table 1

Summary of Reporting on Type B1 Periprosthetic Fractures

Study	No. of Subjects at Final Follow-up	Fracture Type	Study Type	Fixation Type
Haddad et al[23]	4	B1*	Case series	Dall-Miles cables plus strut allograft and cancellous autograft
Tadross et al[24]	7	B1	Case series	Dall-Miles cable-plate
Tsiridis et al[25]	14 (16 fractures)	3 B1, 10 B3, 1 C	Case series	Dall-Miles cable-plate only for B1 fractures
Sen et al[26]	12	B1	Case series	LCP-DCP with trochanteric fixation
Ricci et al[27]	34	B1	Cohort	Single lateral plate
Abhaykumar and Elliott[28]	7	5 B (not subclassified), 2 C	Case series	DCP
Chakravarthy et al[29]	12	6 B1, 6 C	Case series	LCP or LISS
Buttaro et al[30]	14	B1	Case series	LCP ± cortical strut allograft (5 cases)
Haddad et al[31]	39	B1	Multicenter case series	Cortical allograft onlay alone, or lateral plate and one or two allograft cortical onlays

* Described as well-fixed, stable implants

† Mean values for entire series including periprosthetic femur fractures other than fractures around total hip arthroplasties

DCP = dynamic compression plate, LCP = locking compression plate, LISS = less invasive stabilization system, NR = not reported

This is a critical distinction for the treating surgeon to make because loose stems require revision arthroplasty to achieve a satisfactory outcome.

The plain radiographs should be carefully examined for signs of a loose stem—specifically, continuous lucency at the cement-stem–bone interface and continuous lucency at the cement-stem interface. We do not consider a cement mantle fracture alone to represent a loose stem in the case of an acute fracture. Fractures of the cement mantle before acute trauma are indicative of a loose stem. If any doubt remains, the stem should be tested for instability intraoperatively; hip arthrotomy and dislocation are necessary if the distal implant cannot be tested for translation relative to the proximal cement mantle or femur at the level of the fracture.

The feature differentiating the B2 from the B3 fracture is available bone stock; B3 has insufficient bone stock to ensure a predictably good outcome following straightforward revision without more specialized techniques. Both types, however, require revision arthroplasty, in contrast to B1 fractures.

Type C

Type C fractures are well distal to the implant stem and therefore do not affect implant stability. Fixation technique is based on the fracture pattern and its location. Sometimes this will include fixation to the cortex around the distal portion of the stem to extend the span of the fixation plate or to avoid leaving a segment of weak bone between the stress risers of the stem tip and proximal end of the plate.

Management

Many different treatment options have been described for periprosthetic fractures.[22] Outcomes are difficult to assess with certainty. Much of the existing literature is difficult to integrate because of retrospective methods, inconsistent classification, poorly defined outcomes, and series that mix results for combined groups of hip and knee arthroplasty cases (Table 1).

Historically, treatment has included nonsurgical strategies such as protected weight bearing, traction, and casting or bracing. Except in uncommon cases in which the patient is not a candidate for surgery because of medical contraindications, all patients are treated with surgical fixation of the fracture. Unstable fracture patterns managed nonsurgically

Table 1 (continued)

Summary of Reporting on Type B1 Periprosthetic Fractures

Mean Patient Age in Years (Range)	Mean Follow-up in Months (Range)	Union Results
54.3 (43-62)	NR	Union in all cases
76.1 (65-87)	12 (6-18)	Union in 5 cases, 2 of which healed in varus
80.4 (70-87)	16.4 (NR)	All 3 B1 fractures: failure of fixation or nonunion and fixation not achieved >2 cortical diameters beyond the distal fracture line
73 (57-91)	71.8 (46-108)	Union in 10 cases
72 (38-98)	24† (11-170)	Union in 34 cases
83.1 (78-90)	NR	Union in 7 cases
80.2 (72-86)	13.9 (12-18)	Union in 10 cases
68 (72-86)	20 (10-30)	Union in 8 cases
69 (44-93)	28 (6-78)	Union in 39 cases

* Described as well-fixed, stable implants

† Mean values for entire series including periprosthetic femur fractures other than fractures around total hip arthroplasties

DCP = dynamic compression plate, LCP = locking compression plate, LISS = less invasive stabilization system, NR = not reported

Table 2

Considerations in Management of Type B1 Periprosthetic Fractures

Consider occult infection preoperatively
Confirm stability of the implant intraoperatively if in doubt
Use minimal dissection to obtain reduction and apply the plate
Use locked plates with the option to place nonlocked screws anterior and posterior to the femoral stem
Use cables as an adjunctive stabilization technique rather than as a primary technique
Augment poor bone stock with cortical strut allograft secured with cables
Bypass the distal extent of the fracture by at least two cortical diameters
Avoid a stress riser in ipsilateral stemmed TKA by spanning the femoral stem of the TKA
Extensive polyethylene wear plus osteolysis ± a malpositioned acetabular component requires acetabular revision either in a single stage or on a delayed basis following union of the femoral fracture

TKA = total knee arthroplasty

have historically required prolonged in-patient admission and recumbancy and were associated with delayed time to mobilization and a higher likelihood of nonunion and malunion compared with surgical care.[32]

Modern techniques of surgical fixation have largely replaced nonsurgical techniques except for protected weight bearing in highly selected cases. Internal fixation provides optimal fracture reduction, a superior biologic local environment for healing because of biomechanical stability, and, ultimately, the most rapid mobilization of the patient.[12] Many techniques have been described, most commonly involving cable-plate devices or plating, with either compression or locking plates.

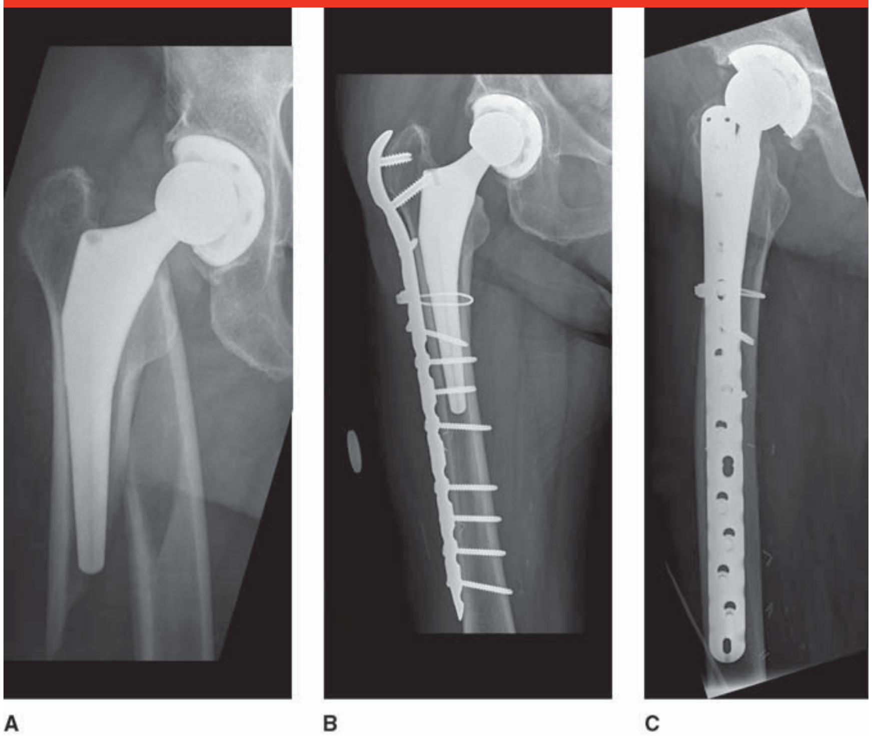
Surgical Principles

Once the decision to proceed with surgery has been made, several important principles should be incorporated, including adequate preoperative planning, surgical approaches that minimize soft-tissue trauma, and the use of robust implants with sufficient length and fixation proximally, at the level of the stem, and distally (Table 2). Appropriate preoperative assessment and planning is required. The extent and stability of the fracture, the degree of bone loss, and poor bone quality may not be fully appreciated until directly visualized. Preoperative planning should include a surgical approach if the stem is found to be unstable by intraoperative assessment. In addition to a standard revision arthroplasty complement, implants and allograft for unexpected intraoperative findings should be available.

Regardless of the fixation technique, understanding the biology of fracture healing is important, particularly in relation to the preservation of blood supply to the fracture fragments and surrounding soft tissues. This is best accomplished by limiting surgical dissection to the minimum needed for adequate reduction and fixation. One component of optimization of the biology of healing is accurate fracture reduction, through either open or indirect means. Residual malalignment can predispose to treatment failure.

Use of robust fixation is necessary

Figure 2



Treatment of a periprosthetic femoral B1 fracture with open reduction and internal fixation (ORIF). **A,** Preoperative AP radiograph demonstrating a B1 femoral fracture. Postoperative AP **(B)** and lateral **(C)** radiographs demonstrating ORIF of the fracture with the use of a proximal femoral plate with a combination of locking and nonlocking screws, as well as the use of a cable attached to the plate through a locked eyelet. Slight radiolucency of unknown significance is noted in the acetabulum. The patient is being followed serially.

because these fractures are typically slow to heal, and associated osteopenia is frequently involved. Fixation according to AO principles of relative stability, as opposed to absolute stability, can be useful, particularly in the setting of comminuted fractures, to allow bridging of the comminuted segment. The use of fixed-angle implants, using an angled blade plate or locking plate, is helpful for fixation of the distal fragment. The use of locking plates may provide an advantage in osteopenic bone. Fixation in the proximal fragment is commonly difficult and may require use of multiple components, such as locking screws, conventional screws, and cables attached to the plate through eyelets. Cables alone should be used only when screw fixation is not technically possible. Their use in conjunction with screws can add valuable stability with a large canal-filling stem (Figure 2). Finally, fixation close to the fracture and at the far ends of the plate should be employed to maximize the overall strength of the construct.

Postoperative management should be individualized according to the patient characteristics and the stability of the construct. Patients should be mobilized as quickly as possible. In most cases, toe-touch weight bearing is recommended until definitive healing has been demonstrated at a minimum of 12 weeks, at which time activities are advanced. Appropriate thromboprophylaxis and antibiotic prophylaxis should be administered.

Cable-plate Devices

Since the concept of the Ogden plate (Zimmer, Warsaw, IN) emerged nearly 30 years ago, cable-plate systems have gained in popularity. The Dall-Miles cable-plate system (Stryker Howmedica, Mahwah, NJ) was first described by Berman and Zamarin.[33] A small series reported by Haddad et al[23] suggested that excellent outcomes could be obtained with this fixation method. Tadross et al[24] reported that, in a series of seven periprosthetic femur fractures treated with the Dall-Miles cable and plate, there were three nonunions, and four of the seven treated fractures were considered failures, two for nonunion and two for malunion. The authors postulated that varus malpositioning of the femoral implant altered the biomechanics of the fracture and compromised anatomic union. This suggests that use of a cable-plate system alone may not provide sufficient stability for these fractures.

Tsiridis and colleagues[25,34] suggested that augmentation of the Dall-Miles plate with either a long-stem revision or cortical strut allograft was required because the cable-plate construct used alone resulted in failure in 43% of fractures around the stem. Of 16 fractures (14 patients), there were 10 Vancouver type B3, 3 B1, and 3 C fractures.[25] Two of the three B1 fractures were treated with open reduction and internal fixation (ORIF) following nonunion with use of the cable-plate system. Each of the nonunions was associated with insufficient bypass of the fracture site by at least two cortical diameters. The authors recommended supplemental fixation with long-stem revision or strut allograft, depending on the stability of the reconstruction.[25] It should be noted that most fractures in these studies[25,34] were type B3 injuries, for which fixation is not the recommended treatment. The necessity of augmentation of this fixation method was further recommended in a study of 20 fractures around a stable femoral stem, including 15 B1 injuries.[35] Union was achieved in all 15 type B1 fractures, but 2 cases of varus malunion were reported. The authors proposed that varus alignment occurred because of the torsional instability of the cable-plate construct.

Compression and Locking Plates

ORIF has been a standard method of plate fixation of B1 periprosthetic fractures. The advantage of this method is the direct visualization and reduction of the fracture and the rigid internal fixation afforded by compression plates. The disadvantage relates to the amount of soft-tissue dissection required and the potential difficulty in obtaining bicortical screw fixation because of intramedullary fill by the stem and cement. In an attempt to minimize the extent of soft-tissue dissection, indirect reduction and percutaneous insertion of plates and screws has been proposed—the so-called minimally invasive plate osteosynthesis technique. This can be used either with standard compression plates or with newer locking plate technology.

These methods of fixation have been investigated in numerous studies. In a series of 12 patients with a B1 fracture reported by Sen et al,[26] each patient was treated with ORIF using a low-contact dynamic compression plate. Ten fractures (83%) united at an average of 7 months. The mean Harris hip score was 85 (range, 75 to 94) at a mean follow-up of 6.5 years.

The use of dynamic compression plating following open reduction was reported by Ricci et al.[27,36] There were 41 patients with a femoral fracture associated with stable intramedullary femoral implants around THAs studied in the final analysis. The authors reported 100% union by an average of 12 weeks. There was one instance of cable fracture and one early and two late infections, each of which resolved. Prefracture functional status was attained in 30 (73%) of patients and was decreased in 11 (27%).

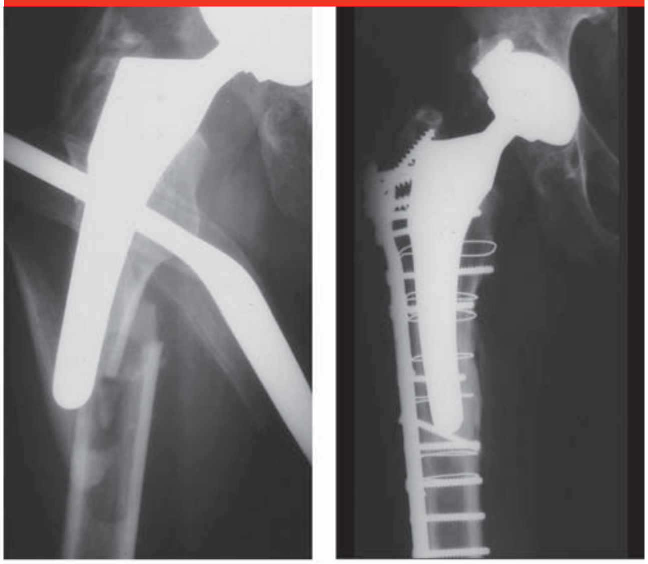
Minimally invasive percutaneous plating has gained popularity in recent years, including application in B1 fractures. This technique is challenging because it relies on limited direct or indirect fracture reduction with limited visualization of both the fracture and fixation construct. The proposed advantage is minimization of trauma related to soft-tissue dissection in the local biologic environment of the fracture. This advantage can be further used through application of locking plate fixation, allowing for unicortical screw fixation as well as improved fixation in osteopenic bone. A series of seven periprosthetic femoral fractures managed with a minimally invasive submuscular technique was described by Abhaykumar and Elliott.[28] A 100% union rate and full mobility were achieved by 5 months in all seven cases. There were five type B fractures, which were not subclassified, and two type C fractures.

The shift in philosophy toward minimally invasive fixation techniques has been coupled with locking plate technology in the management of B1 fractures. The interpretation of results using the devices is difficult because locked plating may confound the result of minimally invasive techniques. Chakravarthy et al[29] treated 12 patients with a mean age of 80.2 years (range, 72 to 86) with Vancouver B1 or C fractures with a locking compression plate or less invasive stabilization system (LISS) plate. Eleven patients were available for analysis at a mean follow-up of 13.9 months. There were 10 instances of union, which occurred at a median of 4.8 months. There was one implant failure after fracture union: the patient sustained a fracture between the distal plate tip and an ipsilateral total knee arthroplasty (TKA) femoral component because of a stress riser effect of the plate ending less than two cortical diameters proximal to the femoral component of the TKA. The authors suggested that, particularly for osteoporotic bone, locked plating is an effective option for periprosthetic femur fractures.

Technical tips were offered by Ricci et al[36] for the use of indirect fracture reduction and minimally invasive plating. The plate must be of sufficient length to allow as much overlap of the prosthesis as possible, bypassing the implant by a minimum of six screws. Stress risers should be avoided at the proximal and distal extent of the plate. Locked plates should be used wherever possible in osteoporotic bone. Cables can be combined with the fixation construct, particularly if attached to the plate using locking eyelet attachments (Figure 3). In conjunction with minimally invasive principles, soft-tissue dissection should be minimized.

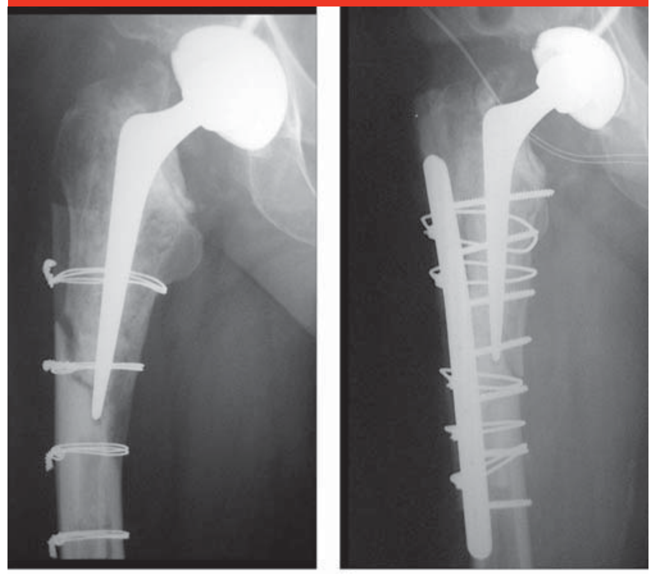
Buttaro et al[30] reported on a consecutive series of 14 B1 fractures treated with a locked compression plate following open reduction. Five cases included supplemental fixation with a cortical strut allograft; however, the indication was not specified. The average follow-up was 20 months, and there were eight instances of fracture union at an aver-

Figure 3



A, Preoperative AP radiograph demonstrating a type B1 periprosthetic femoral fracture. **B,** Postoperative AP radiograph demonstrating treatment with ORIF using a large-fragment plate with a combination of nonlocking screws and cables attached to the plate through locking eyelets. The nonlocking screws can be angled for optimal fixation around the femoral stem. Locking screws cannot be angled in this fashion. The lucency in the acetabulum may be related to osteolysis and is being followed serially. Prior to sustaining the fracture, the patient was asymptomatic.

Figure 4



A, AP radiograph demonstrating a type B1 periprosthetic femoral fracture following revision arthroplasty using impaction grafting. The fracture occurred even though the reconstruction was protected with a lateral cortical strut allograft secured with cables. **B,** Postoperative AP radiograph demonstrating fixation with a combined lateral and anterior cortical strut allograft and cable plating. Fracture following application of a cortical strut allograft may require maximal fixation, as is achieved with combined anterior and lateral cortical strut allograft.

age of 5.4 months. The remaining six patients experienced failure, related in three to plate fracture and in three to plate pullout. All but one of these failures occurred in the absence of a cortical strut allograft. The authors referred to B1 fractures as "inherently unstable," which is not in keeping with the definition of a B1 fracture.[10,11] If, in fact, the fractures were misclassified such that unstable injuries were treated as stable fractures, that circumstance may explain the high proportion of fixation failures. This scenario has been encountered in other studies.[16,37]

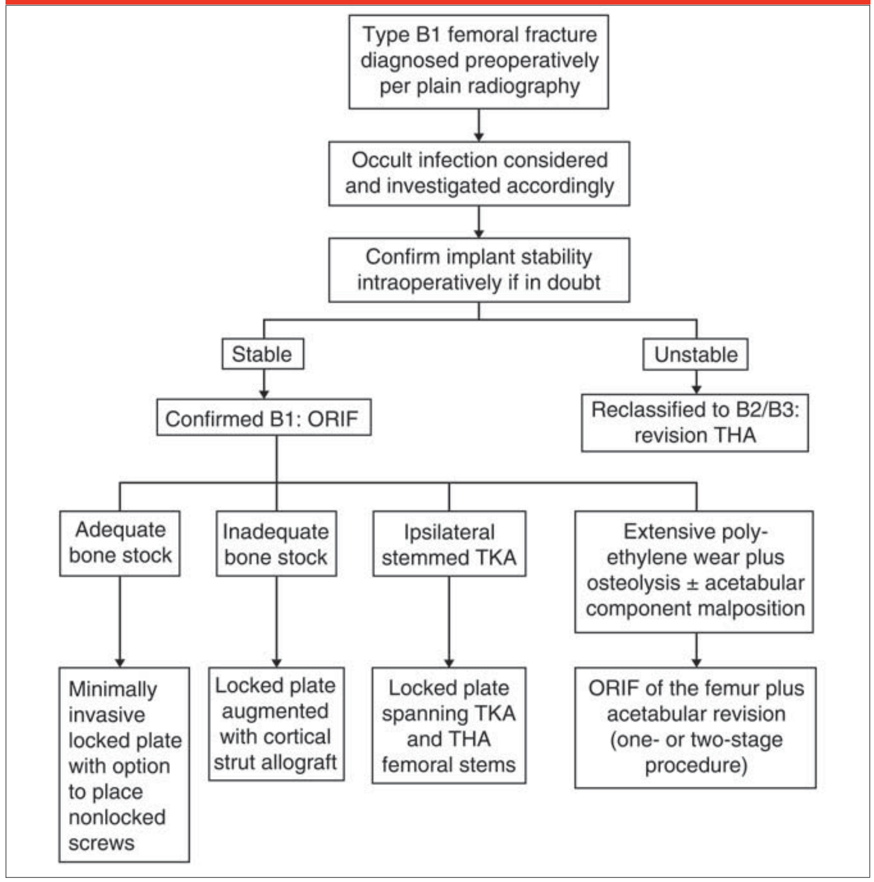
Haddad et al[31] reported the results of 40 cases at four centers of postoperative Vancouver B1 fractures treated with cortical onlay allografts alone or in combination with a plate. Nineteen patients were treated with allograft cortical struts and 21 with a strut graft and dynamic compression plating. All but one united, and although malunion occurred in four, the extent was <10° in each case. The one fracture that failed to unite initially did unite after a single further intervention using the same technique—a plate and allograft strut. Although this method has been associated with a high likelihood of fracture union, we currently favor a more minimally invasive approach for fracture fixation. Future prospective studies comparing these techniques are warranted.

The authors of a biomechanical study recommended combining lateral plating with placement of an anterior cortical allograft strut as the most stable construct[38] (Figure 4). The fracture model for the study was a B1 fracture. The disadvantage to this method is the excessive soft-tissue dissection required. Although the optimal stability was estimated in this study, it is unknown what degree of stability is needed for fracture union and, furthermore, what is the ideal method of obtaining this degree of fixation.

Treatment Recommendations

Little direct comparative evidence exists for the different treatment options. Consideration of several principles aids in the management of these difficult fractures. Our current recommendation for B1 fractures is plate fixation, with either a compression plate or a locking plate, applied in a minimally invasive fashion. Particular features of the fracture, bone stock, the presence of an ipsilateral stemmed TKA, and the status of the acetabular component are notable factors in management (Figure 5). It is important that a plan be formulated preoperatively in preparation for the possible finding of an unstable femoral stem.

Figure 5



Algorithm for managing B1 periprosthetic femoral fractures. ORIF = open reduction and internal fixation, THA = total hip arthroplasty, TKA = total knee arthroplasty

An unstable femoral implant is usually revealed on plain radiographs by a continuous lucency at the cement-bone interface or cement-implant interface. We do not consider cement mantle fractures alone to be indicative of a loose stem. If the bone-cement and cement-implant interfaces are intact without lucency, the stem is considered to be stable. When the stability of the implant is questionable, it must be tested intraoperatively. 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. This can be performed with a pointed reduction forceps on the femur and a Kocher forceps grasping the stem tip. If such a maneuver is not possible, a formal arthrotomy and posterior dislocation by a posterolateral approach is necessary to gain adequate exposure to exclude instability.

If the femoral stem is deemed to be stable on preoperative imaging and a B1 fracture is the final diagnosis in the absence of extensive polyethylene wear or osteolysis, the fracture is managed with ORIF. Malposition of the acetabular component alone in a patient who was asymptomatic before sustaining a periprosthetic fracture is not addressed in the acute setting. However, when extensive polyethylene wear plus osteolysis with or without a malpositioned cup is encountered, an acetabular revision is performed either in a single stage or as a second stage after healing of the periprosthetic fracture. Acetabular revision and ORIF of the femur can be performed through an extensile posterolateral approach. Such acetabular revision necessitates a revision hip arthroplasty, with the surgeon prepared to remove the acetabular components, address bone loss, and implant a revision acetabular component.

Appropriate patient positioning and surgical approach greatly facilitate reduction and application of the plate. We have found that the lateral decubitus position provides reliable access intraoperatively to the hip and entire femur as deemed necessary. Intraoperative imaging with the patient in the lateral position, although somewhat more difficult than in the supine position, is attainable. The direct lateral approach to the femur affords the easiest access to the femoral diaphysis, with extension to a posterolateral approach to the hip joint if stability of the implant is questioned. The posterolateral approach to the hip allows the most flexibility for conversion to revision THA if the implant is unexpectedly found to be unstable.

It is important that the biology of fracture healing be understood and accurate fracture reduction achieved.

Figure 6

AP radiograph showing failed fixation following ORIF with a short plate and cables passed around the femur at the level of the implant. This technique provided insufficient proximal fixation.

We advocate using strictly the minimal degree of dissection necessary to obtain an accurate reduction. In cases with adequate bone stock and simple fracture configuration, exposure of the fracture site with a single reduction clamp and gentle traction from the surgical assistant may be all that is necessary to achieve a reduction. A submuscular plate may then be positioned through the wound, with its position confirmed with fluoroscopy. Locked screws can be inserted percutaneously in many systems, thereby minimizing the need for further soft-tissue dissection. However, fixation around the stem with nonlocked screws positioned anterior and posterior to the implant or circumferential cables may require greater soft-tissue dissection. When reduction is not achieved through a minimal window at the level of the fracture, the wound must be extended to allow for direct control of the fracture fragments.

Many types of plates are available to maintain the reduction, none of which has demonstrated superiority. We favor locked plates with the option for nonlocked screw placement. Although locking improves the fixation proximally and distally, particularly in poor bone, the angle of insertion is fixed or of limited variability. Achieving fixation around the stem necessitates the ability to place either nonlocked screws anterior and posterior to the stem or cables around or through the plate, as in cable-plate constructs. Another advantage of plates with combined locked and nonlocked screw options is the capacity to generate compression at the fracture site in suitable simple fracture patterns, such as transverse and short oblique types. Often the fixation afforded by nonlocked screws anterior and posterior to the stem obviates the need for cable augmentation and the associated soft-tissue stripping it demands. Once the fracture is stabilized and compressed, locked screws can be placed proximally and distally to create a fixed-angle device. Failure to achieve adequate fixation proximally, at the level of the stem, and distally can lead to catastrophic failure (Figure 6).

In terms of plate length, we aim to bypass the distal tip of the femoral stem and the distal extent of the fracture by at least two cortical diameters. If the bone quality is deficient, as judged intraoperatively, we will increase the length of the plate to achieve more sites of fixation. Proximal fixation into the greater trochanter is also important to increase proximal fixation. These principles usually dictate a plate extending from the vastus ridge proximally and ending distally with three to five bicortical screws distal to the fracture.

Other considerations include augmentation of bone stock and avoidance of stress risers. Cortical strut allograft, applied parallel and adjacent to the plate and secured with cables, can be used in cases of inadequate bone stock. The additional support provided to the underlying native bone as it heals and remodels must be weighed against the greater dissection necessary to apply them. It is important for the plate to span stemmed TKAs if present. Failure to do so results in a stress riser susceptible to fracture in the future.

Long-term Outcome

Need for Revision Surgery

In a review of the Swedish National Hip Arthroplasty Registry, Lindahl et al[16] reviewed 1,049 periprosthetic fractures, of which 304 (29%) were B1 injuries. Following treatment of the fractures, the risk of failure of fixation was 33.9% among those treated with plate fixation and 43.9% among those treated initially with cerclage wire fixation. Of the 304 B1 fractures, 200 (66%) were treated with ORIF and 72 (24%) required additional surgery. The authors concluded that fracture misclassification was responsible for the high proportion of failure of ORIF. They further recommended, on the basis of this experience, that treatment consist of stem revision when there is any doubt about the stability of the femoral component. Using revision as the end point, Lindahl et al[16] reported the 10-year survival rate for persons with these injuries to be 73.2% following primary THA and 64.9% following revision THA, with a combined overall survival rate of 69.9%.

Mortality

Bhattacharyya et al[39] reviewed 106 patients treated surgically for a periprosthetic femoral fracture and compared this group with an age- and sex-matched group of control patients who sustained a hip fracture and a second matched group treated with primary THA or TKA. The 1-year mortality rate among those with a periprosthetic fracture was 11%, compared with 16.5% for a hip fracture and 2.9% in the primary arthroplasty group.

Lindahl et al[40] also reviewed mortality rates after periprosthetic fracture in the Swedish National Hip Arthroplasty Register between 1979 and 2000. For patients aged 70 years, the increased mortality likelihood (versus that of age-matched controls) for men was 2.1% and for women 1.2%; for patients aged 80 years, it was 3.9% for men and 2.2% for women.

Summary

The accurate diagnosis and successful management of postoperative periprosthetic fractures requires an appreciation of the classification and management options to guide appropriate treatment. The goal of treatment is to optimize long-term function by restoring stability to the fracture, thereby maintaining stability of the THA components and allowing for fracture union. Treatment algorithms based on the fracture classification and implant stability have been developed and represent the current best means by which to accomplish the treatment goals. Future study is required, particularly by comparative study designs, to delineate the preferred methods of fixation for these fractures. The current recommendation is the use of either compression or locking plate fixation following indirect fracture reduction using a minimally invasive technique when appropriate.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, there are no level I or level II studies. References 18-21, 31, and 38 are level III studies. References 1-4, 6, 7, 15-17, 22-30, 32-37, 39, and 40 are level IV studies. References 5 and 8-14 are level V studies.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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