Intraoperative Periprosthetic Fractures During Total Hip Arthroplasty. Evaluation and Management

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Intraoperative periprosthetic fractures are becoming more common given the increased prevalence of revision total hip arthroplasty and increased use of cementless fixation.

Risk factors for intraoperative periprosthetic fractures include the use of minimally invasive techniques; the use of press-fit cementless stems; revision operations, especially when a long cementless stem is used or when a short stem with impaction allografting is used; female sex; metabolic bone disease; bone diseases leading to altered morphology such as Paget disease; and technical errors at the time of the operation.

Appropriate treatment of intraoperative periprosthetic fractures does not compromise the long-term results of total hip arthroplasty unless the bone damage precludes stable fixation of the implant.

Total hip arthroplasty is a highly successful procedure with a high likelihood of excellent long-term results and a relatively low risk of complications. One of the major complications of total hip arthroplasty is periprosthetic fracture. Although both postoperative and intraoperative fractures occur, it is the former that have received the greatest attention in the literature. Despite this, the prevalence of intraoperative periprosthetic fractures is increasing. It is imperative that the modern reconstructive hip surgeon be familiar with the classification and treatment of these complications. Only intraoperative fractures will be considered in this review.

Intraoperative Femoral Fractures

Epidemiology and Etiology

Intraoperative periprosthetic femoral fractures have received greater attention in the literature than have acetabular fractures, possibly because of the difficulty in identifying intraoperative acetabular fractures at the time of the operation. The risk of an intraoperative femoral fracture has been shown to be greatest when a cementless component is used in revision total hip arthroplasty. In one study, an intraoperative femoral fracture was encountered during 1% (238) of 23,980 primary total hip arthroplasties compared with 7.8% (497) of 6349 revisions, and subsequent studies have demonstrated similar results. In the study mentioned above, the rate of periprosthetic fracture during primary total hip arthroplasty was 5.4% (170 of 3121) when a cementless femoral component was used compared with 0.3% (sixty-eight of 20,859) when a cemented stem was used. Other studies demonstrated a prevalence of intraoperative fracture of 1.2% (seven of 605) when a cemented stem was used and 3% (thirty-nine of 1318) when a cementless femoral component was used. The variability in the reported prevalences of periprosthetic fractures may reflect differences between studies with regard to sample size or the use of different femoral stems and insertion techniques. Sarvilinna et al. reported an odds ratio of 0.6 (95% confidence interval, 0.2 to 1.9) for the occurrence of a fracture in association with use of a cementless femoral stem compared with use of a cemented stem in a small case-control study that predominantly included postoperative fractures. These results must be in-
Interpreted with caution since there was substantial variability surrounding the estimate of the odds ratio. The prevalence of intraoperative fractures is increased in the revision setting. In one series of 175 cementless revision procedures, the reported fracture rate was 19% (thirty-four of 175)\(^2\). In another study, the prevalence of intraoperative fractures in association with uncemented stems in the revision setting was reported to be 20.9% (322 of 1536) compared with only 3% (thirty-nine of 1318) in association with cemented stems\(^3\).

Lerch et al.\(^2\) reported a case-control study in which forty-two patients with an intraoperative femoral fracture were compared with forty-two controls who did not have a fracture. All fractures occurred in association with uncemented stems. Forty of the forty-two fractures united, and there were two instances of nonunion of a fracture in the greater trochanter with trochanteric migration. There were no differences in the Harris hip scores, Short Form-36 (SF-36) scores, or postoperative complications between the two groups.

**Risk Factors**

The risk factors for intraoperative femoral fractures have been more widely reported than those for acetabular fractures. There is an increased risk in association with cementless stems, especially in the revision setting. This is predominantly due to the need for press-fitting of cementless stems in conjunction with the bone loss typically associated with revision total hip arthroplasty. The potential mismatch between the bow of the femur and the bow of the stem is accentuated by the use of a long revision stem, increasing the risk of intraoperative fracture. Issack et al.\(^2\) reported an intraoperative fracture during fourteen (8%) of 175 cementless revision total hip arthroplasties in which a porous-coated, distally slotted, fluted stem was used. Other techniques used in revision total hip arthroplasty, in particular impaction bone-grafting, may increase the risk of fracture. Use of prophylactic cerclage wiring, longer stems, and possibly cortical onlay allografts\(^12,15\) should be considered in conjunction with this technique. The prevalence of intraoperative femoral fracture during impaction bone-grafting has been reported to be between 4% (three of sixty-eight) and 32% (twenty-two of sixty-eight)\(^22-34\). Farfalli et al.\(^2\) reported a series of fifty-nine intraoperative fractures that had occurred during revision total hip arthroplasty with impaction bone-grafting. There were thirty-four fracture (58%) and twenty-five instances of cortical perforation (42%). The majority of the fractures (44%) occurred during cement removal, while seven fractures (12%) occurred during allograft impaction and twenty-six (44%) were diagnosed in the immediate postoperative period.

The impact of minimally invasive techniques was studied by Asayama et al.\(^8\), who reported an intraoperative fracture in two of fifty-two patients treated with a limited-incision direct lateral approach for a primary total hip arthroplasty. There were no fractures in patients treated with a standard incision, defined as one >10 cm in length. Moroni et al.\(^36\) investigated risk factors for intraoperative femoral fractures in a retrospective study of 3566 total hip arthroplasties, during which eighty-three fractures occurred. The only significant risk factors were female sex, use of an uncemented femoral stem, previous surgery on the affected hip, and revision total hip arthroplasty (p < 0.05). The authors did not utilize a logistic regression analysis to determine the risk; consequently, the magnitude of the risk and the possible confounding effects of those variables are unknown.

Several patient characteristics may be associated with an increased risk of intraoperative fracture. Female sex and increased age have been suggested to be independent risk factors; however, these factors may be confounded by osteoporosis. Medical comorbidities, in particular rheumatoid arthritis, have been suggested to be risk factors, but they may be similarly confounded by associated osteopenia\(^9,10\). Altered bone morphology or deformity, as seen in Paget disease\(^11\), can also increase the risk of fracture.

There is a multifactorial impact on the risk of intraoperative femoral fracture in the setting of revision total hip arthroplasty. The increasing number of revision procedures in older patients introduces the effect of osteopenia, osteolysis, or stress-shielding with subsequent bone defects as well as the presence of stress-risers related to previous procedures. Underreaming of the femoral cortex, use of a large-diameter femoral stem, and a low ratio between the diameters of the femoral cortex and canal have been associated with a greater risk of intraoperative fracture\(^9\).

**Diagnosis**

The surgeon must have a high index of suspicion for iatrogenic fractures. During insertion of the stem, particularly an uncemented component, a sudden change in resistance is highly suggestive of a femoral fracture. Intraoperative radiographs should be made to rule out fracture when a concern is raised. It should be noted that a nondisplaced fracture may not be visualized on radiographs, emphasizing the need to combine intraoperative clinical assessment with the imaging findings in order to diagnose all fractures. The stability of the component, particularly an uncemented stem, must be ensured prior to closure.

**Classification**

It has been recommended that treatment of both intraoperative and postoperative fractures be based on the classification of the injury\(^11,16\). The Vancouver classification for intraoperative fractures (Fig. 1) can be used to guide management\(^11,19\), although, in contrast to the Vancouver classification system for postoperative fractures, its reliability and validity have not been tested\(^40\). The intraoperative classification takes into account the location, pattern, and stability of the fracture. Intraoperative fractures are classified as type A if they involve the proximal metaphysis, type B if the fracture is diaphyseal, and type C if the fracture is distal to the stem tip and not amenable to insertion of the longest revision stem. Each type is further subclassified as subtype 1 if there is only a cortical perforation, subtype 2 if there is a nondisplaced crack, and subtype 3 if there is a displaced unstable fracture pattern.
Treatment and Results

Accurate classification of the fracture type allows appropriate management\(^{1,39}\). We are not aware of any comparative studies providing evidence regarding the ideal treatment of these various fracture types. The principles of treatment include ensuring stability of the total hip arthroplasty components and the fracture, avoidance of fracture propagation, and maintenance of component position and alignment. Adherence to these principles should provide the greatest chance for good long-term outcomes, and these principles are likely to remain constant regardless of changes in technology or surgical techniques.

In our experience, type-A1 fractures have usually been stable and can be treated with bone graft alone, usually obtained from the acetabular reaming. We prefer to treat type-A2 fractures with placement of cerclage wire before the stem is inserted to prevent propagation if a proximally coated stem is used. While there is no solid evidence for this recommendation, it makes sense to stabilize these fractures, particularly because the addition of cerclage wire adds very little morbidity and is a rapid procedure that does not compromise, and possible improves, outcomes. The implant is usually stable with this construct. If a fully porous-coated stem is used, the fracture may be ignored as long as there is no distal propagation of the fracture line. Type-A3 fractures can be treated with a porous-coated diaphysis-fitting stem or a tapered-fluted stem. The above two recommendations are based on our experience and on basic biomechanical principles. An isolated fracture of the greater trochanter can be treated with trochanteric fixation with wires, cables, or a claw-plate (Fig. 2) in order to reduce and stabilize the fracture, in keeping with basic orthopaedic principles. These fractures do not preclude the use of cement, but care must be taken to occlude breaches in the cortex to achieve an effective cement mantle during pressurization, to protect important neurovascular structures from injury due to extruded cement, and to ensure that there is no cement between the fracture fragments.

Type-B1 fractures usually occur during cement removal and can be treated by bypassing the affected area by two cor-
tactical diameters with a longer stem; this magnitude of bypass has been shown to provide sufficient stability. Allograft cortical struts can be used to supplement fixation. Type-B2 fractures usually result from increased hoop stress during placement of either the broach or the implant. These injuries may be missed intraoperatively, in which case they are usually diagnosed on postoperative radiographs. If they are diagnosed intraoperatively, management can consist of placement of cerclage wire as long as the implant is stable (Fig. 3). If implant stability has been compromised, one should consider bypassing the defect, if possible. Cortical allograft may be used if the bone quality is deemed to be poor or if the fracture cannot be bypassed with the stem. If these injuries are diagnosed postoperatively, treatment should consist of protected weight-bearing and close observation. Type-B3 injuries usually occur during hip dislocation, cement removal, or final stem insertion. These fractures can be treated by bypassing the fracture site with a longer stem and using cortical allograft if necessary (Figs. 4-A and 4-B).

Type-C1 fractures usually occur during cement removal or canal preparation and can be treated with morselized bone graft and by bypassing the fracture site as well as use of cortical onlay allografts. Treatment of type-C2 fractures can consist of use of cerclage wires and augmentation with an allograft cortical strut (Figs. 5-A and 5-B), whereas type-C3 fractures can be treated with open reduction and internal fixation (Figs. 6-A, 6-B, and 6-C).

The reported results of treatment of intraoperative femoral fractures are difficult to compare because different fixation strategies have been used; there have been no comparative studies, to our knowledge; and there has been a lack of consistency in the classification of the fractures.

Early reports described various methods of treatment for intraoperative fractures. Khan and O’Driscoll reported on seventeen fractures, with the short oblique fractures treated with a standard femoral implant, the long oblique fractures treated with open reduction and internal fixation, and the fractures distal to the stem tip treated with skeletal traction. This third method, although thought appropriate at the time of the study, would not be recommended currently, illustrating the difficulty in the interpretation of the literature.

Farfalli et al. utilized cerclage wires for all vertical perforations, metaphyseal fractures, and trochanteric fractures. Patients younger than sixty-five years of age were treated with placement of a cortical allograft with impacted bone graft and a cemented short femoral stem. If a cemented stem is used, special care must be taken to ensure that there is no cement within the fracture lines because of the associated increased risk of nonunion. The preference at our center is to bypass the fracture with a cementless diaphysis-fitting stem and to augment the fixation with cerclage wiring and possibly a cortical allograft. These treatment options have not, however, been evaluated in a comparative study, to our knowledge. Chappell and Lachiewicz described fifty-four consecutive cementless revision total hip arthroplasties associated with a total of nine femoral fractures. Eight of those fractures occurred during insertion of a curved stem and one, during exposure of the femur. The fractures were treated with cortical allografts and protected weight-bearing, with a successful result in six cases. Berend et al. reported on 1320 primary total hip arthroplasties done with use of an uncemented femoral stem. There were fifty-eight intraoperative calcar fractures, which were treated with cerclage wires or cables and unrestricted weight-bearing postoperatively. At the time of follow-up, at a mean of 7.5 years and a minimum of two years, no patient had undergone a revision.

There have been few recent investigations of modern treatment techniques for intraoperative fractures. Paprosky and Aribindi described one intraoperative fracture among eighty-seven patients treated with an extensively porous-coated, bowed, cementless revision stem with a bullet tip (Solution; DePuy, Warsaw, Indiana); a longer curved stem was used to bypass the fracture. Duwelius et al. reported two intraoperative fractures that had propagated distal to the lesser trochanter and were treated with two cerclage wires with no complications.

To our knowledge, the largest study of intraoperative femoral fractures at the time of revision total hip arthroplasty was reported by Meek et al. Of 211 consecutive patients, sixty-four (30%) sustained an intraoperative femoral fracture and 147 did not sustain a fracture. An extensively coated femoral stem for which a diaphyseal fit had been obtained had been used in all patients. The fractures were classified with use of the Vancouver system, and the most prevalent type was...
B2 (observed in thirty-nine cases [61%]) followed by B1 (observed in eleven [17%]). The risk factors for intraoperative fracture were substantial bone loss, a low ratio between the cortical and canal diameters, underreaming of the femoral canal, and use of a large-diameter stem. A wide variety of treatment modalities were used, with the most common being cerclage wire fixation (in twenty-five cases [39%]) followed by placement of an allograft cortical strut (in eighteen [28%]). At a minimum of two years postoperatively, there was no difference in the functional outcome according to the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) or the Oxford-12 or SF-36 outcome measures. Thirty-three patients were available for radiographic evaluation at a minimum of two years postoperatively; bone ingrowth of the stem was noted in 97% of them, and a stable fibrous union was noted in 3%. No significant difference in the prevalence of stable fractures was found when bowed and straight stems were compared or when 10-in (25-cm) and 8-in (20.3-cm) stems were compared. However, 10-in stems had been used more frequently in the group with an unstable fracture.

Biomechanical studies have been performed to compare the strengths of different fixation constructs. Schmotzer et al. studied several different constructs and reported that cables were stronger than cerclage wires; dynamic plates were better than Ogden plates; and, for the treatment of unstable fractures, revision with a long cementless stem should be supplemented with allograft cortical struts. Another biomechanical study demonstrated that plate constructs with only screws or screws combined with cables provided the greatest fixation stability. Use of double plates (one anterior and one lateral) has been demonstrated to provide greater stability than use of a single lateral plate with wires; however, the authors of that report acknowledged the disadvantage of the requisite additional soft-tissue dissection required with the double-plate strategy. Wilson et al. reported that the ideal construct for a fracture with a stable femoral stem was a lateral plate supplemented with an anterior allograft cortical strut. Although the ideal stability has been considered in these studies, the minimum stability required for successful union remains unknown. This issue affects all of the reported biomechanical findings and is
relevant given the need for the use of allograft bone, which may not be readily available in all centers, and the additional soft-tissue dissection required to place the grafts. We are not aware of any studies comparing the combination of standard dynamic compression plates and allograft with more modern fixation devices, such as locking plates. These issues should be considered in the interpretation of in vitro biomechanical studies.

**Intraoperative Acetabular Fractures**

**Epidemiology and Etiology**

Intraoperative periprosthetic fractures of the acetabulum are less commonly recognized than femoral fractures. They are reportedly more common in association with uncemented cups. In 1974, McElfresh and Coventry reported only one intraoperative periprosthetic acetabular fracture during 5400 total hip arthroplasties performed with cement (a prevalence of <0.02%); however, as a result of the infrequent attention to intraoperative acetabular fractures in the literature, this may be an underestimate. Haidukewych et al. reviewed a series of 7121 primary total hip arthroplasties and reported an intraoperative acetabular fracture during twenty-one (0.4%) of 5359 performed with an uncemented acetabular component. No acetabular fractures occurred during any of the 1762 procedures done with a cemented component. Of the twenty-one fractures, seventeen were stable and four were treated with supplemental screw fixation. Elliptical monoblock cups were associated with the highest risk of fracture, with a prevalence of 3.5% (twelve) of 339 compared with a prevalence of 0.09% (two of 2198) in association with hemispherical modular shells. Sharkey et al. reported that thirteen intraoperative acetabular fractures occurred during the insertion of uncemented components; nine were diagnosed intraoperatively. Various treatment methods were employed, including additional screw fixation, autogenous bone-grafting, and protected weight-bearing. Two cases required revision of the acetabular component, one patient died in the immediate postoperative period, and ten acetabular components remained unrevised after a maximum duration of follow-up of fifty-nine months.

Intraoperative acetabular fractures most frequently occur during insertion of the component. This is due to the underreaming required for the fixation of a cementless acetabular component when no screws are used. In order to minimize the risk of fracture, it has been suggested that components not be oversized by >2 mm. It should be noted that the 2-mm rule applies for average acetabular diameters. When very large cups are used, it may be appropriate to oversize by >2 mm, depending on the clinical circumstances and the quality of the bone, although we are not aware of any data regarding this issue. Patient factors contributing to the risk of these fractures include osteopenia, metabolic bone disease, and osteolytic defects. Factors related to the operative technique include aggressive reaming and the use of a cup in which the rim circumference is larger than the nominal diameter of the cup.

**Diagnosis**

Maintaining a high index of suspicion for intraoperative acetabular fractures is important as they can be difficult to identify. When a concern arises regarding a possible fracture, a full clinical and radiographic assessment of the affected area is required. This should include careful determination of com-

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**Fig. 4-A**

Figs. 4-A and 4-B Treatment of a type-B3 fracture with cerclage wire fixation supplemented with an allograft cortical strut. **Fig. 4-A** Intraoperative appearance.

**Fig. 4-B**

Postoperative anteroposterior radiograph.
ponent stability with use of intraoperative stress testing of the pelvis and the acetabular component, and it may require removal of the cup to fully examine the acetabulum.

**Classification**

Intraoperative acetabular fractures were classified by Callaghan et al.\textsuperscript{17,18} on the basis of in vitro investigation. Their classification system identifies four types of fractures on the basis of the anatomic location: anterior wall, transverse, inferior lip, and posterior wall.

Della Valle et al.\textsuperscript{56} classified acetabular fractures, including both intraoperative and postoperative types. Type-I fractures occur intraoperatively at the time of insertion of the acetabular component and are subclassified as type A if they are diagnosed intraoperatively, are undisplaced, and are associated with a stable component; as type B if they are diagnosed intraoperatively but are associated with a displaced fracture; and as type C if they are diagnosed postoperatively. It can be difficult to differentiate between undisplaced and displaced fractures intraoperatively, which highlights the importance of obtaining and considering both intraoperative and radiographic findings. Type-II injuries occur at the time of component removal and are further classified as type A if there is <50% loss of acetabular bone stock and as type B if there is >50% loss of acetabular bone stock. The remaining fracture types comprise postoperative injuries and are beyond the scope of this review. In our opinion, this is a cumbersome classification system and the most important factors are whether the implant is stable in association with the intraoperative or postoperative fracture and whether there is pelvic discontinuity in the presence of failure of the acetabular component with massive osteolysis. Therefore, we propose the following addition to the Vancouver classification system of periprosthetic fractures\textsuperscript{11,39}, as it applies to the acetabulum intraoperatively: type I—an undisplaced fracture that does not compromise the stability of the component; type II—an undisplaced fracture that potentially compromises the stability of the reconstruction, such as a transverse fracture of the acetabulum (with pelvic discontinuity or dissociation) or an oblique fracture that separates the anterior column and dome from the posterior column (a much less common injury); and type III—a displaced fracture. By definition, if there is substantial displacement, the fixation of the cup will be compromised unless the fracture is somehow stabilized (Figs. 7-A and 7-B).
Although this classification has not been validated or widely utilized, it has been useful in the assessment and management of intraoperative acetabular fractures at our center.

**Treatment and Results**

The goal of treatment is to maximize hip function. Although the exact treatment methods may change over time, the principles include fracture stabilization, prevention of propagation of the fracture, maintenance of component alignment and stability, and achievement of fracture union. 

Little attention has been paid in the literature to the treatment and outcome of intraoperative acetabular fractures. In the study by Sharkey et al., of thirteen fractures, six were treated with additional acetabular screw fixation, two were deemed stable and not in need of additional fixation or a change in postoperative rehabilitation, and one did not require additional fixation but was treated with non-weight-bearing for eight weeks postoperatively. Fracture union was observed in all nine cases. The remaining four fractures, identified postoperatively, were associated with evidence of loosening on follow-up radiographs, and two required revision. While firm conclusions cannot be made on the basis of this study because of the small sample size, there is a trend toward failure if an unstable fracture is not stabilized, as was seen in the cases of the unrecognized fractures. We are not aware of any comparative studies in the literature regarding the treatment of acetabular fractures.

Della Valle et al. offered recommendations for treatment of intraoperative acetabular fractures. According to these authors, when a patient has a nondisplaced fracture with a stable component, the prosthesis can be left in situ and standard total hip arthroplasty rehabilitation protocols may be applied. If the component is unstable, the structural integrity of the anterior and posterior columns must be assessed and supplemental screw fixation should be used if necessary. Consideration should be given to the use of a so-called jumbo revision cup if there is marked instability and bone loss that necessitates the use of a larger acetabular component. These fractures should be further treated with bone graft, and the patient should maintain protected weight-bearing postoperatively until the fracture has healed. If there is substantial motion at the fracture site, including the presence of pelvic dissociation, the posterior column should be treated with reduction and internal fixation (with, for example, a pelvic reconstruction plate on the posterior column; Figs. 7-A and 7-B). After the pelvis has been stabilized, the acetabulum may be reconstructed with standard techniques. We are not aware of any prospective studies in which these treatment recommendations were investigated.

Posterior column internal fixation alone may not be sufficient for some cases of pelvic dissociation; alternate techniques may be required. Fixation with a reconstruction cage and bone-grafting may be appropriate in such cases, as the cage will bridge from inferiorly to superiorly and allow temporary stabilization of the fracture while the bone graft incorporates and the fracture heals. If acetabular bone loss is so severe that a standard hemispherical cementless cup may provide unreliable fixation and bone ingrowth, an alternate fixation method may be required. Such cases may be treated with a porous tantalum substrate such as the one used for the Trabecular Metal Revision Cup (Zimmer, Warsaw, Indiana), which allows more predictable bone ingrowth. In 2005, Springer et al. reported on seven women who had a delayed transverse fracture of the acetabulum after undergoing a revision total hip arthroplasty with a Trabecular Metal Cup. The authors thought that these fractures were not intraoperative but were related to the weak remaining bone stock, which failed after resumption of activity. The occurrence of these fractures and their displacement with time suggest that a cup that bridges from superiorly to inferiorly and has a high capacity for bone ingrowth may not be sufficient in cases of severe bone loss. For this reason, pelvic discontinuity should not be treated with a hemispherical cup alone. Instead, stability may be achieved by the addition of a reconstruction cage that is designed to fit within the cup and is fixed to the ischium inferiorly and to the ilium superiorly. An all-polyethylene cup can then be cemented into the reconstruction cage (Fig. 8).

This is the so-called cup-cage-construct technique. Boscainos
et al.\textsuperscript{58} reported good early results in fourteen patients treated with the cup-cage construct, although the rate of recurrent dislocation was high, with two of the fourteen patients requiring revision to a constrained acetabular liner. Both of these studies\textsuperscript{57,58} only described the use of this technique in revision total hip arthroplasty; consequently, the use of this technique for intraoperative acetabular fractures has not been reported, to our knowledge.
Prevention of Intraoperative Periprosthetic Fractures

Prevention of periprosthetic fractures requires preoperative planning to assess risk factors associated with their occurrence. This includes obtaining a detailed history and formulating an operative plan. Full-length, adequate preoperative radiographs, including Judet views, should be made in order to

Fig. 7-A

Figs. 7-A and 7-B A type-III intraoperative acetabular fracture of the floor and both columns of the acetabulum. Fig. 7-A Initial anteroposterior radiograph of the pelvis, demonstrating the fracture.

Fig. 7-B

Anteroposterior radiograph of the pelvis following open reduction and internal fixation of the acetabulum with an anterior column screw and a posterior column plate followed by acetabular reconstruction and implantation of a standard femoral component.
fully appreciate any deformity or areas of bone loss that may increase susceptibility to fracture. All potential reconstructive options should be carefully planned with use of templates on preoperative radiographs to anticipate the likely sizes of the components. It should be emphasized that, if the implant chosen on the basis of the templating is not stable, the surgeon should carefully inspect the femur to make sure that there is no fracture that is creating instability and failure of fixation.

During the course of the operation, careful attention must be given to the parts of the procedure that are associated with the highest risk of fracture, such as hip dislocation, cement removal (in revision cases), canal preparation, and component insertion. Adequate soft-tissue releases are necessary to minimize the force required to obtain sufficient exposure. If necessary, adjunctive surgical strategies, such as an extended trochanteric osteotomy, should be considered. This is particularly relevant to the removal of well-fixed cementless and precoated cemented stems. The use of cerclage wires at the distal extent of a trochanteric osteotomy, or of a periprosthetic fracture, should be considered to prevent propagation of the fracture. Appropriate thin hemispherical osteotomes could be used for the acetabular component, and trephines should be used for the femoral stem. During canal preparation, eccentric reaming should be avoided and consideration should be given to protecting areas of bone loss with cerclage wires or bone graft. In the setting of complex revision, intraoperative radiographs can be made to ensure central placement of the guidewire within the medullary canal prior to reaming. Immediate postoperative radiographs should be made to assess for potential fractures that were not appreciated intraoperatively.

**Overview**

Intraoperative periprosthetic fractures are an increasingly common problem. They are particularly likely to occur at the time of a revision total hip arthroplasty in which uncemented components are used. Appropriate steps should be taken to minimize the risk of fracture through the identification of high-risk situations. A high index of suspicion is required to identify possible fractures. The Vancouver classification may be used to facilitate an understanding of the fracture pattern and to choose treatment. Management should be directed toward ensuring component stability, thereby maximizing the chance for fracture union and a satisfactory outcome. Future comparative studies of fixation techniques for intraoperative fractures are necessary to optimize management of these injuries.

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