The Journal of Arthroplasty Vol. 22 No. 4 Suppl. 1 2007

Periprosthetic Fractures of the Knee

David Backstein, MD, MEd, FRCSC, Oleg Safir, MD, FRCSC, and Allan Gross, MD, FRCSC

Abstract: Periprosthetic total knee arthroplasty fractures of the distal femur and proximal tibia can be among the most difficult complications to effectively manage within the realm of joint replacement. These fractures can occur intraoperatively or postoperatively. Intraoperative fractures can be avoided by early removal of hardware, use of stems for stress risers, and use of intraoperative radiographs whenever further visualization is required. Intraoperative fractures should be fixed and then protected by a stem and avoidance of weight bearing until healed. Postoperative fractures can occur with significant trauma, or minor injury when osteolysis is present. Operative management is almost always required. The method of treatment depends upon factors such as the stability of implant fixation, location of the fracture, quality of the bone, and presence or absence of an open-box femoral component. **Key words:** total knee arthroplasty, periprosthetic fracture, revision knee arthroplasty.

With an ever-increasing number of total knee arthroplasties (TKAs) being performed each year, the incidence of periprosthetic fractures is likely to continue to rise. Periprosthetic fractures adjacent to knee implants can occur intraoperatively or postoperatively. Fractures can occur in the early postoperative phase as a result of intraoperative technical issues such as the formation of stress risers, excessive patellar bone resection, and cortical perforations [1,2]. Periprosthetic fractures may also occur in the late postoperative phase as a result of trauma or pathologic fracture secondary to osteolysis or osteopenia [3].

Classification

Many classification systems have been described to help guide management of these types of fractures. The classification of Neer et al [4] describes femoral fractures in terms of displacement but does not address the tibial side. Furthermore, Neer's system fails to encompass the prosthesis stability or bone quality. Modifications to the Neer classification by DiGioia and Rubash's classification [5] characterize the parameters of comminution, whereas Chen et al [6] simplify Neer's classification and correlate clinical outcomes to their classification scheme. Both DiGioia and Rubash and Chen et al focus on characteristics of the fracture pattern and do not incorporate the status of a prosthesis or bone. In contrast, the classification system by Rorabeck and Taylor [7] incorporates information about the fracture type as well as the condition of the prosthesis. Recently, Su et al [8] have succinctly summarized the deficiencies of previously published classifications and elaborated a new system for supracondylar fractures around TKA.

Despite a relatively large volume of literature which addresses the management of these complex problems, a simple yet effective classification system has yet to be published. The classification developed at our institution is as follows:

Femur (defined: supracondylar femur fracture within 15 cm of the femoral prosthesis)

Type F1: Extent of distal fracture fragment provides adequate bone for retrograde nail locking screws.

From the Division of Orthopaedic Surgery, Mount Sinai Hospital, University of Toronto, Toronto, Ontario, Canada.
Submitted August 21, 2006; accepted December 12, 2006.
No benefits or funds were received in support of the study.
Reprint requests: David Backstein, MD, MEd, FRCSC, Mount Sinai Hospital, 600 University Avenue, Suite 476D, Toronto, Ontario, Canada M5G 1X5.

0883-5403/07/1906-0004$32.00/0
doi:10.1016/j.arth.2006.12.054

Type F2: Extent of distal fracture fragment does not provide adequate bone for retrograde nail locking screws.

Tibia (defined: tibial fracture within 15 cm of the tibial component)

Type T1: Extent of proximal fracture fragment large enough to allow internal fixation.

Type T2: Extent of proximal fracture fragment not large enough to allow internal fixation.

Additional qualification of all fractures includes the prosthesis stability and the bone stock quality, as follows:

S—Stable prosthesis; L—loose prosthesis
g—Good bone stock; p—poor bone stock

For example, supracondylar periprosthetic fracture of the femur 5 cm from the intercondylar notch with stable implant and with good quality of the bone stock is classified as F1Sg fracture.

The fundamental purpose of this classification system is to differentiate those periprosthetic fractures that can be fixed definitively or temporarily with some method of osteosynthesis, from those that are likely to require revision. This is the primary difference between the type 1 and type 2 fractures in each category. Type 1 fractures are more amenable to intramedullary nail or plate fixation, whereas type 2 are more likely to require revision. The g/p subtype distinction is based on bone quality with subtype p fractures more likely to require structural allografts or megaprostheses for revision than subtype g.

Prevention: Intraoperative and Early Postoperative

Intraoperative or early postoperative periprosthetic fractures may be avoided by several preventative measures. For primary knee arthroplasty, one should consider removal of previously placed hardware at least 3 months before knee arthroplasty, or if removed at the same time as knee arthroplasty, stems should be used to bypass stress risers [9]. Avoidance of eccentric placing of the box cut for posterior stabilized femoral components is critical [9]. In TKA after previous high tibial osteotomy, lateral placement of the tibial component or stem must be avoided as this may lead to perforation of the lateral tibial cortex [9]. If eversion of the patella is found to be difficult, it can be delayed until after the distal femoral cut is made or, ideally, skipped all together. Simply retracting the patella laterally often provides sufficient exposure for TKA and risk to the patella or the patellar tendon is minimized. Integrity of the anterior femoral cortex is at risk as a result of perforation by intramedullary instrumentation or from anterior cortical notching. If a significant perforation (>1 cm in diameter) or notching more than 3 mm does occur, the stress riser should be bypassed with a stem [1].

In revision arthroplasty, guide wires and x-rays can be used before reaming. Stemmed components should be used routinely in revision situations. Intraoperative radiographs should be taken with trial stems in place whenever there is any concern regarding cortical perforation or trial component position [9]. When exposure is suboptimal after thorough clearing of the medial and lateral gutters, a quadriceps snip or tibial tubercle osteotomy is used.

Treatment: Intraoperative and Early Postoperative

The treatment of periprosthetic fractures depends on the stability of the fracture, the stability of the implant, and the quality of the bone stock. Fractures that are identified intraoperatively during primary or revision arthroplasty should be fixed and protected by a stem so that range of motion exercises can proceed as usual, although weight bearing may have to be delayed [9]. These are usually metaphyseal fractures that can be fixed by screws and protected by a stem. Autologous bone graft from reamings or other local sites is always applied to the fracture site, particularly in the setting of comminution. If the fracture is not recognized until the recovery room radiograph and the fracture and the implant are deemed stable, conservative treatment can be considered, recognizing that range of motion exercises and weight bearing will have to be monitored closely so that displacement does not occur [2,5,6,9]. It is our experience that operative fixation is needed in all but the most benign of fracture patterns.

Treatment: Late Postoperative

Fractures that occur postoperatively can be caused by significant trauma or by minimal trauma, if the bone has been weakened by osteolysis, osteoporosis, or osteopenia [3,9]. If the fracture is undisplaced and the implant is stable, conservative treatment can be carried out. This may require restricted weight bearing and protected range of motion (cast brace). Most fractures require surgery and the technique depends upon the stability of the implant and the quality of the bone stock.

Most of these fractures are metaphyseal and adjacent to the implant. If the fracture is diaphyseal and distant from the implant, then the TKA is usually stable and the fracture is fixed using modern plating techniques. Metaphyseal fractures of the femur with a stable implant can be fixed by a buttress plate, a periarticular plate, a locking plate, or a retrograde locking intramedullary nail (Fig. 1). It is the authors' preference to use retrograde nailing whenever the option exists around well-fixed components as this technique is less disruptive to soft tissue attachments to fracture fragments [10]. This technique requires access to the medullary canal through the intercondylar notch which depends upon the type of implant used. Closed-box posterior stabilized implants do not allow this access. The retrograde nailing technique also requires that the fracture not be too distal or comminuted. If the fracture configuration provides less than 20 mm of bone from the intercondylar notch, it is our experience that adequate fixation with locking screws for a retrograde nail is not possible. The use of locking plates for distal fractures or those associated with a closed femoral box has been a major advance. These devices allow for multiple points of fixed angle fixation in the distal fragment. There is emerging evidence in support of their use for situations where the component is well fixed but the fracture is too distal for intramedullary nailing [10]. Whenever open fixation techniques are used, an attempt to apply autologous bone graft from a local site is made, particularly if there is fracture comminution.

Fig. 1. A, Supracondylar periprosthetic fracture. B, Internal fixation by retrograde locking nail.

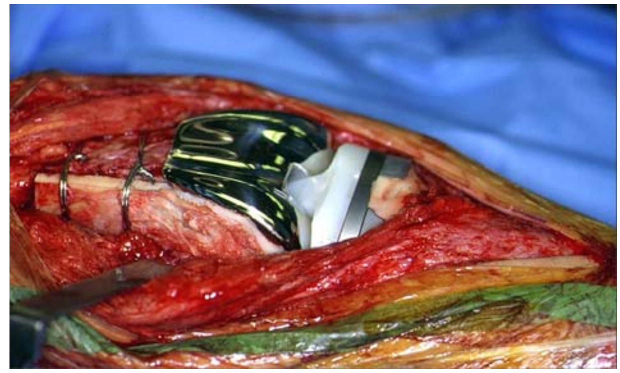

Fig. 2. Intraoperative picture of distal femoral allograft.

Metaphyseal fractures of the tibia are not as common as the femur. If the implant is stable, these fractures can be managed by buttress plates or periarticular plates. Fractures of either the femur or tibia in association with an unstable implant require revision with stemmed components. The stem should provide some fixation for the fracture, but additional internal fixation may be necessary. As a rule, we recommend that stems should not be cemented unless the patient is of very low physiologic demand and unlikely to require further revision surgery. A cemented stem may interfere with fracture healing and would also make further surgery very difficult.

The most difficult periprosthetic fracture is one with loose implants combined with poor bone stock. Once loose implants are removed from a periprosthetic fracture, there are often major bone deficiencies. Revision can be carried out with augments to replace mild to moderate bone loss (approximately 2 cm on the femoral side and 5 cm on the tibial side). Augments can compensate for greater bone loss on the tibial side because of the combination of metal augments and thicker polyethylene. If the bone loss is beyond augments, then either a megaprosthesis or structural allograft-implant composite must be used [11,12]. A megaprosthesis has the advantages of being free of allograft to host bone interfaces that need to heal and no problems of graft resorption or fracture. Megaprostheses disadvantages include the inability to reattach ligaments or the patellar tendon, and they usually require a rotating hinge for stability. A structural allograft-implant composite does allow reattachment of soft tissue and bone, does not

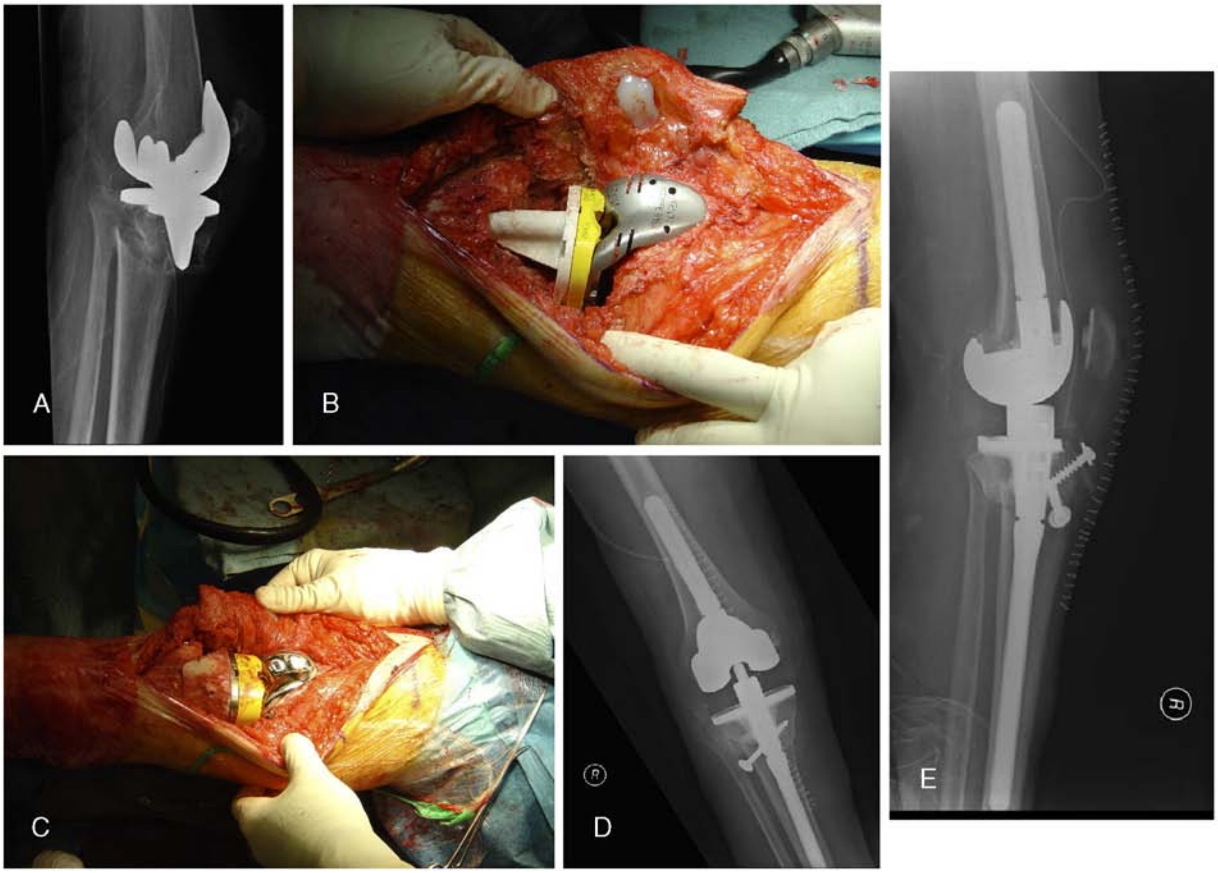

Fig. 3. A, Lateral view of periprosthetic fracture of proximal tibia with loose implant. B, Intraoperative picture of large bone defect after implant removal. C, Intraoperative picture after insertion of the proximal tibial allograft. D, Anteroposterior view of postoperative x-rays of the knee revision with the proximal tibial allograft. E, Lateral view of postoperative x-rays of the knee revision with the proximal tibial allograft.

require a rotating hinge, and restores bone stock for future surgery. In addition, press fit stems can be used to stabilize the allograft prosthetic composite, whereas with megaprostheses the stem must be cemented or porous coated, making another revision difficult. We believe that megaprostheses are better suited for immunocompromised patients, and patients who are on chemotherapy after resection of primary bone tumors around the knee rather than the standard arthroplasty population. In a recent publication from our institution, 10 consecutive patients who underwent revision TKA with distal femoral implant-allograft composites for treatment of periprosthetic supracondylar fractures associated with major bone loss were reviewed [12]. The average postoperative Hospital for Special Surgery and SF-36 scores were 75 and 88, respectively. Nine of 10 patients achieved radiographic union, showed no migration, no loosening, and were able to fully bear weight.

Allograft-prosthetic composite reconstruction allows reattachment of residual host bone with its attached host collateral ligaments and thus a constrained, rather than a hinged, prosthesis can be used [12,13]. The implant is cemented to the allograft but not the host. The junction of host and allograft is stabilized by a press fit stem (not cemented and not porous coated) and a step cut or oblique osteotomy (Fig. 2). The host canal is therefore available for future revision surgery if necessary. On the tibial side, the patellar tendon with host tuberosity can be fixed to the allograft if needed [13] (Fig. 3).

Discussion

The ultimate goal of periprosthetic fracture treatment has been described by Cain et al [14] as a pain-free knee with fracture union within 6 months to allow ambulation and a range of motion to 90°. More recently, management goals were described by Rorabeck et al [15]. Their objectives encompass those of Cain et al but add that 2-cm shortening and 5° malalignment in the varus/valgus plane or 10° malalignment in the sagittal plane is acceptable [15].

A simple and reliable classification system can assist surgeons in obtaining optimal clinical results for their patients by allowing for better communication of the best treatment modalities particular to specific fracture patterns. We feel that the strength of our classification system is its connection to a treatment algorithm which can be used to direct management decisions.

References

1. Zalzal P, Backstein D, Gross AE, et al. Notching of the anterior femoral cortex during total knee arthroplasty characteristics that increase local stresses. J Arthroplasty 2006;21:737.
2. Hirsch D, Bhalla S, Roffman M. Supracondylar fractures of the femur following total knee replacement. J Bone Joint Surg 1981;63A:162.
3. Bogoch E, Hastings D, Gross A, et al. Supracondylar fractures of the femur adjacent to resurfacing and MacIntosh arthroplasties of the knee in patients with rheumatoid arthritis. Clin Orthop 1988;229:213.
4. Neer II CS, Grantham SA, Shelton ML. Supracondylar fracture of the adult femur. Study of one hundred and ten cases. J Bone Joint Surg Am 1967;49:591.
5. DiGioia AM, Rubash HE. Periprosthetic fractures of the femur after total knee arthroplasty. A literature review and treatment algorithm. Clin Orthop Relat Res 1991;271:135.
6. Chen F, Mont MA, Bachner RS. Management of ipsilateral supracondylar femur fractures following total knee arthroplasty. J Arthroplasty 1994;9:521.
7. Rorabeck CH, Taylor JW. Classification of periprosthetic fractures complicating total knee arthroplasty. Orthop Clin North Am 1999;30:209.
8. Su ET, DeWal H, Di Cesare PE. Periprosthetic femoral fractures above total knee replacements. J Am Acad Orthop Surg 2004;12:12.
9. Gross AE. Periprosthetic fractures of the knee: puzzle pieces. J Arthroplasty 2004;19(4 Suppl):47.
10. Ricci W, Loftus T, Cox C, et al. Locked plates combined with minimally invasive insertion for the treatment of periprosthetic supracondylar femur fractures above a total knee arthroplasty. J Orthop Trauma 2006;20:190.
11. Wong P, Gross AE. The use of structural allografts for treating periprosthetic fractures about the hip and knee. Orthop Clin North Am 1999;30:259.
12. Kassab M, Zalzal P, Azores G, et al. Management of periprosthetic femoral fractures after total knee replacement using a distal femoral allograft. J Arthroplasty 2004;19:361.
13. Clatworthy MG, Balance J, Brick GW, et al. The use of structural allografts for uncontained defects in revision total knee arthroplasty. A minimum 5 year review. J Bone Joint Surg Am 2001;83:404.
14. Cain PR, Rubash HE, Wissinger HA, et al. Periprosthetic femoral fractures following total knee arthroplasty. Clin Orthop 1986;208:205.
15. Rorabeck CH, Angliss RD, Lewis PL. Fractures of the femur, tibia, and patella after total knee arthoplasty: decision making and principles of management. Instr Course Lect 1998;47:449.