Periprosthetic fractures following total knee arthroplasty are a potentially devastating complication to both the patient and the surgeon. Complication rates of treatment reported in the literature range widely, from 25 to 75 percent, even in the hands of both skilled and experienced surgeons\(^1-4\). A meta-analysis of 195 fractures in twelve published reports of ipsilateral supracondylar femoral fractures demonstrated complication rates of 30 percent with both nonoperative and operative treatment methods\(^5\). Various treatment modalities have been utilized to manage these challenging fractures. The purpose of this review is to analyze the prevalence, pathogenesis, mechanism of injury, risk factors, classification, and treatment of these fractures.

**Supracondylar Femoral Fractures**

**Prevalence and Pathogenesis**

The reported prevalence of supracondylar femoral fracture following total knee arthroplasty has ranged from 0.3 to 2.5 percent\(^3,6-12\). Various factors have been implicated in the pathogenesis of this fracture. These include stress-shielding from the anterior flange of the femoral component, inadequate osseous remodeling due to postoperative hypovascularity, a relative difference in elastic modulus between the implant-covered distal part of the femur and the femoral cortex, endosteal ischemia from metal or bone cement\(^13,14\), and osteolysis of the distal part of the femur secondary to polyethylene wear debris\(^15\).

The majority of these fractures result from a combination of axial and torsional loads\(^10,16,17\). Most occur following minimal falls, whereas others are secondary to motor-vehicle accidents, seizures, or closed manipulation of a stiff knee after total knee arthroplasty\(^18\).

**Risk Factors**

A review of the literature shows that patients with conditions associated with osteopenia are clearly at greater risk of sustaining a supracondylar femoral fracture after total knee arthroplasty\(^4-7,10,19-24\). Patients with rheumatoid arthritis\(^2,4,7,18,19,24\), those being treated with corticosteroids\(^4,5,18,22,24\), those of advanced age\(^4,10\), and females\(^8,11,14,18,19,25,26\) are all at greater risk for supracondylar femoral fracture. Additional risk factors include neurological disorders\(^8\), a previous revision total knee arthroplasty\(^6,27\), and rotationally constrained implants that create increased torsional load transfer to bone\(^2,28\).

Both clinical and biomechanical data strongly suggest that anterior notching of the distal femoral cortex increases the risk of this fracture, with 40 to 52 percent of reported fractures associated with an anterior notch\(^2,5,6,7,10,19,20,30\). A theoretical mathematical analysis revealed that a three-millimeter notch results in a 30 percent reduction in torsional bone strength\(^10\). A biomechanical analysis of cadaveric femora revealed a mean reduction of 18 percent in bending strength and a mean decrease of 42 percent in torsional strength when a full-thickness anterior notch was present\(^19\). Ritter et al.\(^13\), however, in a review of 670 total knee arthroplasties, observed that 138 femora (20.6 percent) exhibited a notch of at least three millimeters; yet, a supracondylar fracture developed in only two. This finding emphasizes the potential for osseous remodeling to decrease the risk of fracture should an anterior notch occur.

To reduce the risk of supracondylar femoral fracture after total knee arthroplasty, use of walking aids by patients with substantial osteopenia and an unsteady gait pattern is recommended. Additionally, should an anterior notch of the distal part of the femur be created intraoperatively, the surgeon should consider implantation of a femoral component with an attached diaphysis-engaging stem to support the weakened distal part of the femur.

**Classification**

Numerous systems of classification of supracondylar femoral fractures after total knee arthroplasty have been developed\(^12-34\). The system found most
valuable in my management of these fractures was created by Rorabeck et al.34. Their classification takes into account both the status of the prosthesis (that is, whether it is intact or failing) and the displacement of the fracture. Type I is assigned if the fracture is undisplaced and the prosthesis is intact; type II, if the fracture is displaced and the prosthesis is intact; and type III, if the fracture is displaced or undisplaced and the prosthesis is loose or failing (that is, if there is substantial instability or polyethylene wear).33

Treatment Options
The goals of treatment are to obtain and maintain good postfracture alignment and stability to allow early range of motion10,33,35,36. There are a myriad of both nonoperative and operative treatment options for the management of supracondylar femoral fractures. The nonoperative options include skeletal traction, application of a cast, pins and plaster, and cast-bracing. The operative options include use of a condylar plate; intramedullary fixation, either flexible or rigid (interlocking); revision total knee arthroplasty; external fixation; cerclage wiring with strut allograft fixation; and arthrodesis. Determination of clearly superior treatment methods is difficult because of the limited number of cases that have been evaluated in most reports33. While fracture configuration plays a role in the choice of treatment method, fracture displacement, the degree of osteopenia, and the status of the prosthetic components (intact or failing) are my primary determinants of the fracture management method. Treatment results are closely associated with postfracture alignment and stability.14,22,27,33-35. Fracture displacement, intercondylar extension, and comminution are negative prognostic factors.27 High malunion rates are common in association with varus, flexion, and internal rotation deformities typically seen as a result of forces exerted by the adductor and gastrocnemius muscle groups.3 Varus femoral malunion is associated with a risk of premature failure of the total knee arthroplasty. Figgie et al.3 reported on twelve fractures that had united with varus malposition of the femoral component. Progressive radiolucent lines at the bone-cement interface were seen in nine of the twelve cases. The superiority of nonoperative4,8,18,19,27,38-40 over operative2,3,10,12,14,26,35-37,41-49 treatment has been controversial. Chen et al.5 performed a review of twelve published studies (195 fractures) and found no significant difference (p < 0.90) between the prevalence of successful results in the nonoperative treatment group (67 percent) and that in the operative group (69 percent). More recently, operative treatment has been shown to provide better results when used for displaced fractures45,48,50, probably because of improvements in surgical techniques and the available fracture fixation devices. Moran et al.48 reviewed a series of twenty-four cases of displaced supracondylar fracture after total knee arthroplasty. Nine fractures were managed nonoperatively and all nine

Fig. 1-A Anteroposterior radiograph of a minimally displaced supracondylar femoral fracture in a patient with advanced osteopenia. Fig. 1-B Anteroposterior radiograph made six months following nonoperative treatment with cast immobilization. Despite corrective reduction and cast-wedging, a valgus malunion resulted.
had an unsatisfactory result, primarily because of malunion. Fifteen were managed with open reduction and internal fixation, and ten had a satisfactory result. The choice of treatment method should be based on the patient’s health, fracture displacement, comminution, severity of osteopenia, and status of the prosthetic components (loose, unstable, or malaligned).

**Nonoperative Treatment**

The advantages of nonoperative treatment are that it is noninvasive and the infection rate is negligible. Union is likely, particularly in nondisplaced fractures. Nonoperative treatment is uniformly recommended as the initial management of nondisplaced fractures. Chen et al. found an 83 percent rate of successful results in a literature review. Disadvantages include a relatively high malunion rate and functional loss, particularly in patients with a displaced fracture through osteopenic bone, in whom maintenance of reduction is difficult. Additionally, nonoperative treatment often requires prolonged immobilization, which leads to loss of motion and reduced walking capacity. Culp et al. reported the results in thirty patients treated nonoperatively. Fifteen patients (50 percent) had increased pain or decreased ambulatory status following nonoperative care, whereas this was true of only 13 percent of patients treated operatively. Use of a cast resulted in an average loss of motion of 26 degrees. Harlow and Hofmann performed a literature review that included 142 supracondylar fractures following total knee arthroplasty that were treated nonoperatively. Twenty-nine percent of these fractures eventually required operative care.

In summary, nonoperative treatment is best reserved for nondisplaced fractures that do not demonstrate intercondylar extension. Nonoperative treatment of displaced fractures can be attempted with initial closed reduction and subsequent immobilization, although accurate maintenance of reduction of fractures through osteopenic bone is often difficult, with malunion commonly occurring (Figs. 1-A and 1-B). I favor an initial four-to-six-week period of cast immobilization, followed by a gentle range of motion in a hinged knee brace under the guidance of a physiotherapist. If nonoperative management is selected, biweekly radiographs for the first six weeks are recommended to closely monitor fracture alignment.

**Operative Treatment**

Open reduction and fixation with a condylar plate provides the potential advantages of anatomical reconstruction, rigid fixation, and an early range of motion. Maintenance of reduction can be a problem, particularly when a patient has a comminuted fracture through osteopenic bone, and malunion is commonly observed (Figs. 2-A through 2-D). Figgie et al. reviewed ten cases in which this treatment method was utilized. Fracture alignment was lost in eight. In cases of substantial osteopenia of the distal femoral fragment, adjunctive use of polymethylmethacrylate to enhance fixation may
improve results, as evidenced by the 100 percent success rate without malunion in the six cases reported on by Zehntner and Ganz. Additionally, Healy et al. advocated packing strips of cortico cancellous allograft into the distal femoral fracture to augment condylar plate fixation (Fig. 3). Others have utilized intramedullary fibular graft placed in a retrograde fashion to enhance plate-and-screw fixation. Use of a condylar plate is best reserved for less comminuted, displaced fractures with satisfactory bone stock.

Use of flexible intramedullary rods is an efficient and less invasive treatment option. Shortening and rotational malunion occasionally occur as a result of the reduced axial and rotational stability provided by this technique. Ritter et al. reviewed twenty-two cases treated with Rush rods and found that union had been obtained in 100 percent without a major complication. This technique should be considered for mildly displaced fractures in patients in poor health. It is a minimally invasive procedure with limited morbidity.

Rigid supracondylar interlocking rod fixation offers the advantage of being minimally invasive while providing good axial, angular, and rotational stability in most cases. It can be performed with use of a minimal patellar-tendon-splitting approach with percutaneous placement of interlocking screws in cases with lesser comminution, with maintenance of the fracture hematoma and osseous blood supply (Figs. 4-A through 4-F). Contraindications include a long preexisting total hip intramedullary stem, loose total knee components, severe comminution, and an extremely distal fracture. This method of fixation may also be utilized for supracondylar femoral fractures proximal to a posterior cruciate-substituting total knee prosthesis. With these designs, access to the medullary canal may be blocked by the intercondylar box of the femoral component. Maniar et al. described a technique of opening an aperture in the intercondylar femoral box with use of a diamond-tip metal-cutting burr (Midas Rex, Fort Worth, Texas) to allow passage of the interlocking intramedullary rod. Overall, a review of nineteen cases from four published reports revealed union in all cases, no malalignment, and minimal complications.

Revision total knee arthroplasty provides the advantage of stable fixation with a diaphysis-engaging intramedullary femoral stem, allowing early range of motion and weight-bearing. This technique is selected for extremely distal or comminuted fractures when stable fixation is difficult to secure, or for any fracture associated with loose, unstable, or substantially malaligned total knee components. Additionally, revision total knee arthroplasty is frequently required in cases in which nonoperative or other methods of operative treatment have failed. This procedure is often technically demanding, even in the hands of
A skilled arthroplasty surgeon, and it is best reserved for surgeons who have considerable skill and experience in revision total knee arthroplasty. Use of constrained total knee components, despite their risk of premature failure, is frequently required. Markedly comminuted fractures in osteopenic bone may require distal fracture-fragment excision with replacement with either structural allograft or a distal femoral replacement prosthetic component. In the meta-analysis by Chen et al., eleven supracondylar fractures proximal to total knee prostheses were treated with revision total knee arthroplasty. A satisfactory result was obtained in ten cases.

Additional treatment modalities such as external fixation, cerclage wiring with strut allograft fixation, and arthrodesis have been less frequently utilized, and there is a lack of adequate reports on them in the literature. A suggested treatment algorithm is provided in Figure 5.

**Treatment Summary**

Obtaining and maintaining fracture alignment is critical for the success of any treatment method. Rigid fixation allows an early range of motion, resulting in a superior functional result. There is a high probability of success with nonoperative treatment of minimally displaced fractures. Maintenance of reduction of displaced fractures with nonoperative measures is often difficult, particularly when there is associated osteopenia and comminution. Review of more recent studies demonstrates a trend toward superior results with operative treatment of displaced fractures. Use of a condylar plate, which increases the chance of obtaining rigid fixation and allows early range of motion, is best reserved for less comminuted fractures with good bone stock. Revision total knee arthroplasty is recommended for patients with loose, unstable, or substantially malaligned components; severe comminution; an extremely distal fracture; and failure of other treatment methods.

Use of a supracondylar interlocking rod is becoming the treatment of choice for the majority of displaced supracondylar femoral fractures. It provides good axial, angular, and rotational stability. Clinical studies have shown high union rates with minimal complications. Contraindications to this treatment method include a long preexisting intramedullary stem from a previous total hip arthroplasty.
severe comminution, an extremely distal fracture, and failed total knee arthroplasty components.

**Tibial Fractures**

Tibial fracture following total knee arthroplasty is an infrequent complication with a reported prevalence of 0.40 to 1.7 percent. These fractures may occur intraoperatively or postoperatively. Intraoperative fractures occur most commonly during component removal, bone retraction, trial reduction, or preparation for insertion of a stemmed tibial component. There are several etiologies for postoperative tibial fractures. Many occur after traumatic events. Others are associated with malalignment, knee instability, or component loosening. Rand and Coventry observed fifteen stress fractures of the tibia after Geomedic and Polycentric total knee arthroplasty (Howmedica, Rutherford, New Jersey). All cases were associated with axial malalignment and component malposition. Tibial shaft fractures after extended tibial tubercle osteotomy have also been reported.

Tibial fractures were classified by Felix et al. on the basis of their anatomical location and the status of the prosthetic fixation. Type-I fractures involve the tibial plateau and the fixation interface of the tibial component. Type-II fractures occur adjacent to the stem of the tibial component. Fractures distal to the tibial stem are classified as type III, and those involving the tibial tubercle are classified as type IV. In their review of 102 tibial fractures after total knee arthroplasty, Felix et al. observed sixty-one type-I, twenty-two type-II, seventeen type-III, and two type-IV fractures. Eighty-three fractures were classified as type I, twenty-three fractures were classified as type II, and sixteen fractures were classified as type III. The remaining fractures were not classified.

---

Fig. 4-C
Intraoperative fluoroscopic images showing placement of an interlocking screw into a rigid supracondylar intramedullary nail.

Fig. 4-D

Fig. 4-E
Postoperative anteroposterior (Fig. 4-E) and lateral (Fig. 4-F) radiographs made following treatment with an interlocking supracondylar intramedullary nail inserted with use of a percutaneous technique.
fractures occurred postoperatively, and nineteen occurred during the performance of the total knee arthroplasty. These fractures were observed more commonly in female patients.

Treatment of periprosthetic tibial fractures is based on the fracture location and the status of the prosthetic components. Fractures associated with prosthetic loosening or substantial instability are best managed with component revision, typically with a diaphysis-engaging tibial intramedullary stem, and supplementary open reduction and internal fixation of additional fracture fragments, if possible. In cases with a high degree of comminution, excision of fracture fragments and replacement with prosthetic augmentation or structural bone graft may be required. Cases lacking instability, malalignment, or loosening are treated with use of standard principles of tibial fracture care.

**Patellar Fractures**

Patellar fracture is an infrequent complication of total knee arthroplasty, although a prevalence as high as 21 percent has been reported. Various etiologies for patellar fracture have been proposed. The finding that there is an increased prevalence of patellar fracture associated with patellofemoral malalignment is supported by biomechanical studies that demonstrated that contact forces substantially increase with patellofemoral malalignment. Both the eccentricity and the magnitude of patellofemoral loads increase with patellar subluxation, increasing the risk of patellar fracture.

Excessive, asymmetrical, or inadequate patellar resection increases the probability of patellar fracture. Excessive patellar resection, especially if the subchondral bone is removed, predisposes to patellar fracture. Reuben et al. demonstrated that a patellar osteotomy resulting in a patellar osseous thickness of less than fifteen millimeters substantially increases anterior patellar strain. Conversely, minimal patellar resection, resulting in a greater thickness of the patella-patellar component composite, increases patellofemoral joint-reaction forces and tension within the quadriceps tendon. Use of a femoral component with an excessive anteroposterior diameter or implantation of a...
femoral component in a flexed position increases patellofemoral joint-reaction forces and theoretically increases the probability of fracture. Asymmetrical patellar resection can also result in impaired mechanical strength of the patella, particularly if the lateral facet is overresected. Finally, it has been shown that, when the patella is prepared for component fixation, the creation of a large central peg-hole increases anterior patellar strain more than smaller peripheral peg designs do, thereby increasing the risk of fracture.

Surgical disruption of the patellar blood supply, resulting in avascular necrosis, has been associated with patellar fracture. Analyses of patellar blood supply have demonstrated both extrasosseous and intraosseous vascular systems. The extrasosseous system comprises a peripatellar anastomotic ring supplied by six main arteries. The superior portion of the vascular ring passes anterior to the quadriceps tendon, while the inferior portion passes posterior to the patellar tendon through the fat pad. The intraosseous system comprises the midpatellar, polar, and quadriceps tendon blood supplies. The midpatellar vessels penetrate anteriorly through the middle one-third of the patella, branching into both the proximal and the distal pole. The polar vasculature passes through the proximal part of the fat pad, posterior to the patellar tendon, entering the inferior pole of the patella. Scapinelli observed minimal vascular penetration into the superior pole and the periphery of the patella, whereas Bjorkstrom and Goldie demonstrated a superior vascular supply via the quadriceps tendon.

Substantial disruption of patellar vascular systems occurs during routine performance of total knee arthroplasty. The medial superior and inferior genicular arteries are divided during a medial peripatellar arthrotomy. Damage to the lateral inferior genicular artery is common during lateral meniscectomy or fat-pad excision. The lateral superior genicular artery is at risk during lateral retinacular release. The lateral superior genicular artery is at risk when a lateral retinacular release is performed. The intraosseous vascular system can be compromised during creation of fixation holes, particularly large...
central holes. Technetium bone scans following total knee arthroplasty have demonstrated reduced patellar vascularity if a lateral retinacular release had been performed.\textsuperscript{6,7,5} McMahon et al.\textsuperscript{11} also found reduced patellar vascularity following lateral retinacular release, but they determined that fat-pad excision has no detrimental effect. Histological evaluations of patellar specimens following patellar fracture have documented the presence of osteonecrosis.\textsuperscript{64,51}

Component malposition can affect the prevalence, type, severity, and prognosis of patellar fractures.\textsuperscript{65,66,91,92,90} Errors in joint-line position, lower extremity alignment, or patellar coverage by the prosthesis may increase the risk of fracture. Major malalignment has been associated with more complex fracture patterns and a worse prognosis.

Additional risk factors for patellar fracture include increased flexion following total knee arthroplasty, thermal necrosis, and revision total knee arthroplasty. Windsor et al.\textsuperscript{19} reported that patients with knee flexion of greater than 95 degrees generate increased patellar-lofemoral compression forces and frequently have higher activity levels. The heat of polymerization of the polymethyleneacrylate (reported to be as high as 80 to 90 degrees Celsius in total hip arthroplasty) may exceed the coagulation temperature of tissue proteins, causing thermal necrosis of bone.\textsuperscript{61,60,93,10} Grace and Sim\textsuperscript{11} reported that the prevalence of patellar fracture following primary total knee arthroplasty (0.12 percent) was much lower than that after revision total knee arthroplasty (0.61 percent).

Patellar fractures are best avoided through proper patellar resection (duplication of the original patellar thickness and creation of symmetry of medial and lateral facet thickness), use of a smaller peripheral fixation peg design, assurance of central patellar tracking, and maintenance of the patellar blood supply through fat-pad preservation, avoidance of large central fixation peg designs, and preservation of the lateral superior genicular artery if a lateral retinacular release is required.

Treatment of patellar fractures is controversial. Some require no treatment as they may go unrecognized by the patient. Additional options include immobilization, open reduction and internal fixation with or without component revision, partial patellectomy with tendon repair, and total patellectomy.\textsuperscript{65,66,91,92,90} In what I believe is the largest series of patellar fractures presented to date, Ortizguera and Berry\textsuperscript{32} reported on seventy-eight cases. Fractures were classified according to the status of the patellar component fixation, the integrity of the extensor mechanism, and the quality of the remaining bone stock. Nonoperative treatment was highly successful for the management of fractures with a stable patellar component and an intact extensor mechanism. Operative treatment was selected for thirty-one patients. A complication rate of 39 percent (twelve of thirty-one patients) was observed, and sixteen reoperations were required.

Overall, results of operative treatment of patellar fractures have been suboptimal.\textsuperscript{65,66,91,92,90} Nonoperative treatment is recommended as long as there is no component dislocation or loosening and as long as disruption of the extensor mechanism is not complete. Because of the inferior results reported with operative treatment, I favor nonoperative treatment of displaced fractures with substantial associated extensor lag, as long as fixation of the patellar component is maintained. Treatment with immobilization in extension for four to six weeks frequently results in satisfactory restoration of the function of the extensor mechanism.

References

1. Henry SL, Booth RE Jr. Management of supracondylar fractures above total knee prostheses. Tech Orthop. 1995;9:243-52.
2. Bogoch E, Hastings D, Gross A, Oschwend N. Supracondylar fractures of the femur adjacent to resurfacing and MacIntosh arthroplasties of the knee in patients with rheumatoid arthritis. Clin Orthop. 1998;229-231:20.
3. Figgie MP, Goldberg VM, Figgie HE 3d, Sobel M. The results of treatment of supracondylar fracture above total knee arthroplasty. J Arthroplasty. 1990;5:267-76.
4. Minkel K, Johnson EW Jr. Supracondylar fracture of the femur after total knee arthroplasty. J Bone Joint Surg Am. 1986;68:29-43.
5. Chen F, Mont MA, Bachner RS. Management of ipsilateral supracondylar femur fractures following total knee arthroplasty. J Arthroplasty. 1994;9:521-6.
6. Madsen F, NjaegaardaAndersen P, Juhi M, Snepgen O. A custom-made prosthesis for the treatment of supracondylar femoral fractures after total knee arthroplasty: report of four cases. J Orthop Trauma. 1989;3:332-7.
7. Aaron RK, Scott R. Supracondylar fracture of the femur after total knee arthroplasty. Clin Orthop. 1987;219:136-9.
8. Delport PH, Van Audekercke R, Martens M, Muller JC. Conservative treatment of ipsilateral supracondylar femoral fracture after total knee arthroplasty. J Trauma. 1984;24.846-9.
9. Webster DA, Murray DG. Complications of variable axis total knee arthroplasty. Clin Orthop. 1985;193:160-7.
10. Culp RW, Schmidt RG, Hanks G, Mak A, Estehrjl JL Jr, Heppenstall RB. Supracondylar fracture of the femur following prosthetic knee arthroplasty. Clin Orthop. 1987;222:212-22.
11. Hanks GA, Mathews HH, Routsen GW, Loughran TP. Supracondylar fracture of the femur following prosthetic knee arthroplasty. J Arthroplasty. 1989;4:289-92.
12. Rorabeck CH, Taylor JW. Proxiprosthetic fractures of the femur complicating total knee arthroplasty. Clin Orthop. 1993;30:265-7.
13. Rutter MA, Faris PM, Keating EM. Anterior femoral notching and ipsilateral supracondylar femur fracture in total knee arthroplasty. J Arthroplasty. 1989;3:185-7.
14. Short WH, Hootnick DR, Murray DG. Ipsilateral supracondylar femur fractures following knee arthroplasty. Clin Orthop. 1988;158:11-6.
15. Rand JA. Supracondylar fracture of the femur associated with polyethylene wear after total knee arthroplasty. A case report. J Bone Joint Surg Am. 1994;76:1389-93.
16. Hohi M. Fractures about the knee. In: Rockwood CA, Green DP, editors. Fractures in adults. Volume 2. 2nd ed. Philadelphia: JB Lippincott; 1984. p. 1249-54.
17. Insall JN. Fractures of the distal femur. In: Insall JN, editor. Surgery of the knee. New York: Churchill Livingstone; 1984. p. 413-48.
18. Sisto DJ, Lachiewicz PF, Insall JN. Treatment of supracondylar fractures following prosthetic

Printed with permission of the American Academy of Orthopaedic Surgeons. This article, as well as other lectures presented at the Academy’s Annual Meeting, will be available in March 2001 in Instructional Course Lectures, Volume 50. The complete volume can be ordered online at www.aaos.org, or by calling 800-626-6726 (8 A.M.-5 P.M., Central time).

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. No funds were received in support of this study.

Douglas A. Dennis, MD
2425 South Colorado Boulevard, Suite 280, Denver, Colorado 80222

128
arthroplasty of the knee. Clin Orthop. 1985;196:265-72.

19. Hrusch RA, Petrucci F, Roffman M. Supracondylar fracture of the femur following total knee replacement. Report of four cases. J Bone Joint Surg Am. 1981;63:162-3.

20. Schrater J, Meister PC, DeC. Supracondylar fractures of the femur. Clin Orthop. 1979;138:77-83.

21. Jablonski FF, Crawford M. Retrograde intramedullary nailing of supracondylar femur fractures above total knee arthroplasty. A preliminary report of four cases. J Arthroplasty. 1995;10:95-101.

22. Kraya MJ, Goldberg VM, Figgie MP, Figgie HE 3d. Distal femoral reconstrution with allograft/prosthetic reconstruction for treatment of supracondylar fractures in patients with total knee arthroplasty. J Arthroplasty. 1992;7:7-16.

23. Harlow ML, Hofmann AA. Periprosthetic fractures. In: Scott WN, editor. The knee. St. Louis: CV Mosby, 1994. p 1405-7.

24. McLaren AC, Dupont JA, Schroeder DC. Open reduction internal fixation of supracondylar fractures above total knee arthroplasties using the intramedullary supracondylar rod. Clin Orthop. 1994;302:194-8.

25. Rinecker H. Intramedullary nailing for supracondylar fractures after total knee arthroplasty: a new treatment method. J Arthroplasty. 1995;10:37-43.

26. Ayes DC. Supracondylar fracture of the distal femur proximal to a total knee replacement. Instr Course Lect. 1997;46:197-203.

27. Blows SP, Kerur MJH, MacKenney EP. External fixation for femoral shaft fracture after Stanmore total knee replacement. J Bone Joint Surg Br. 1992;74:313-4.

28. Healy WL, Silviski JM, Incavo SJ. Operative treatment of distal femoral fractures proximal to total knee replacements. J Bone Joint Surg Am. 1993;75:27-34.

29. Howes JP, Sisakka SA, Riley TBH. A modified prosthesis with an interlocking nail stem for the treatment of supracondylar femoral fractures following total knee replacement: a report of three cases. Orthopedics Internat. Ed. 1995;3:3038.

30. MacEachem AG, Ling RS. Ununited supracondylar fracture of the femur following Attenborough stabilized gliding knee arthroplasty treated by distal femoral replacement. Injury. 1983;15:214-6.

31. Moran MC, Brick GW, Sledge CB, Dysart SH, Chilen EP. Supracondylar femoral fracture following total knee arthroplasty. Clinic Orthop. 1996;324:196-209.

32. Smith WJ, Martin SL, Mabrey JD. Use of a femoral nail for treatment of a supacondylar fracture of the femur following the use of a total knee arthroplasty. A literature review and treatment algorithm. J Arthroplasty. 1999;21:135-42.

33. Roscoe MW, Goodman SB, Schatzer J. Supracondylar fracture of the femur after GUEPAR total knee arthroplasty. A new treatment method. Clin Orthop. 1989;241:221-3.

34. Booth RE J. Revision total knee arthroplasty. Management of periprosthetic fractures. Orthopedics. 1994;17:845-7.

35. Scott RD. Anterior femoral notching and isplateral supracondylar femoral fracture in total knee arthroplasty. J Arthroplasty. 1988;3:381.

36. Lesh ML, Schneider DJ, Pellegriini BD. Biomechanical evaluation of the effects of anterior cortical notching of the femur in total knee arthroplasty. Orthop Trans. 1998;1999:22:122.

37. DiGioia AM 3d, Rubash HE. Periprosthetic fractures of the femur after total knee arthroplasty. A 26-year follow-up. Orthop Clin North Am. 1998;29(4):679-90.

38. Rorabeck CH, Taylor JW. Classification of periprosthetic fractures complicating total knee arthroplasty. Orthop Clin North Am. 1999;30:209-14.

39. Rorabeck CH, Ancliss RD, Lewis PL. Fractures of the femoral stem and patella after total knee arthroplasty: decision making and principles of management. Instr Course Lect. 1998;47:449-60.

40. Dennis DA. Periprosthetic fractures following total knee arthroplasty. Tech Orthop. 1999;14:138-43.

41. Dennis DA. Periprosthetic fractures following total knee replacement: the good, the bad, and ugly. Orthopedics. 1998;21:1048-50.

42. Cordeiro EN, Costa RC, Carazatto JD, dos Santos Silva J. Periprosthetic fractures in patients with total knee arthroplasties. Clin Orthop. 1990;252:182-9.

43. Ooi DO. Supracondylar fracture of the femur following Attenborough stabilized gliding knee total knee arthroplasty. J Arthroplasty. 1995;10:263-7.

44. Nielsen BF, Petersen VS, Varmarken JE. Fracture of the femur after knee arthroplasty. Acta Orthop Scand. 1988;59:155-7.

45. Sochat DH, Hardinge K. Nonsurgical manage- ment of supracondylar fracture above total knee arthroplasty. Still the nineties option. J Arthroplasty. 1997;12:830-4.

46. Rolston LR, Christ DJ, Halpern A, O’Connor PL, Ryan TG, Uhlman T. Treatment of supracondylar fractures of the femur proximal to a total knee arthroplasty. A report of four cases. J Bone Joint Surg Am. 1995;77:924-31.

47. Murrell GA, Benfield DC. Interchanged supracondylar intramedullary nails for supracondylar fractures after total knee arthroplasty. A new treatment method. J Arthroplasty. 1995;10:37-43.

48. Ritter MA, Stiver P. Supracondylar fracture in a patient with total knee arthroplasty. A case report. Clin Orthop. 1985;193:168-70.

49. Crow PR, Rust MW, Wissinger HA, McClain EJ. Periprosthetic femoral fractures following total knee arthroplasty. Clin Orthop. 1986;209:205-14.

50. Roscoe MW, Goodman SB, Schatzer J. Supracondylar fracture of the femur after GUEPAR total knee arthroplasty. A new treatment method. Clin Orthop. 1989;241:221-3.

51. Booth RE J. Revision total knee arthroplasty. Management of periprosthetic fractures. Orthopedics. 1994;17:845-7.

52. Scott RD. Anterior femoral notching and isplateral supracondylar femoral fracture in total knee arthroplasty. J Arthroplasty. 1988;3:381.

53. Lesh ML, Schneider DJ, Pellegriini BD. Biomechanical evaluation of the effects of anterior cortical notching of the femur in total knee arthroplasty. Orthop Trans. 1998;1999:22:122.

54. DiGioia AM 3d, Rubash HE. Periprosthetic fractures of the femur after total knee arthroplasty. A 26-year follow-up. Orthop Clin North Am. 1998;29(4):679-90.

55. Rorabeck CH, Taylor JW. Classification of periprosthetic fractures complicating total knee arthroplasty. Orthop Clin North Am. 1999;30:209-14.

56. Rorabeck CH, Ancliss RD, Lewis PL. Fractures of the femoral stem and patella after total knee arthroplasty: decision making and principles of management. Instr Course Lect. 1998;47:449-60.

57. Dennis DA. Periprosthetic fractures following total knee arthroplasty. Tech Orthop. 1999;14:138-43.

58. Dennis DA. Periprosthetic fractures following total knee replacement: the good, the bad, and ugly. Orthopedics. 1998;21:1048-50.

59. Cordeiro EN, Costa RC, Carazatto JD, dos Santos Silva J. Periprosthetic fractures in patients with total knee arthroplasties. Clin Orthop. 1990;252:182-9.

60. Ooi DO. Supracondylar fracture of the femur following Attenborough stabilized gliding knee total knee arthroplasty. J Arthroplasty. 1995;10:263-7.

61. Nielsen BF, Petersen VS, Varmarken JE. Fracture of the femur after knee arthroplasty. Acta Orthop Scand. 1988;59:155-7.
83. Stulberg SD, Stulberg BN, Hamati Y, Tsao A. Failure mechanisms of metal-backed patellar components. Clin Orthop. 1988;236:88-105.
84. Rand JA, Gustilo RB. Technique of patellar resurfacing in total knee arthroplasty. Tech Orthop. 1988;3:57-66.
85. Goldstein SA, Coale E, Weiss AP, Grossnickle M, Meiler B, Matthews LS. Patellar surface strain. J Orthop Res. 1986;4:372-7.
86. Brick GW, Scott RD. The patellofemoral component of total knee arthroplasty. Clin Orthop. 1988;231:163-78.
87. Bjorkstrom S, Goldie IF. A study of the arterial supply of the patella in the normal state, in chondromalacia patellae and in osteoarthrosis. Acta Orthop Scand. 1980;51:63-70.
88. Kayler DE, Lyttle D. Surgical interruption of patellar blood supply by total knee arthroplasty. Clin Orthop. 1988;229:221-7.
89. Scapinelli R. Blood supply of the human patella. Its relation to ischaemic necrosis after fracture. J Bone Joint Surg Br. 1967;49:563-70.
90. Scapinelli R. Studies on the vasculature of the human knee joint. Acta Anat. (Basel) 1968;59:295-311.
91. Insall J, Scott WN, Ranawat CS. The total condylar knee prosthesis. A report of two hundred and twenty cases. J Bone Joint Surg Am. 1979;61:173-80.
92. Scott WN, Rubinstein M, Scuderi G. Results after knee replacement with a posterior cruciate-substituting prosthesis. J Bone Joint Surg Am. 1988;70:1163-73.
93. McMahon MS, Scuderi GR, Glashow JL, Scharf SC, Meltzer LP, Scott WN. Scintigraphic determination of patellar viability after excision of infrapatellar fat pad and/or lateral retinacular release in total knee arthroplasty. Clin Orthop. 1990;260:10-6.
94. Scuderi G, Scharf SC, Meltzer LP, Scott WN. The relationship of lateral releases to patella viability in total knee arthroplasty. J Arthroplasty. 1987;2:209-14.
95. Wetzer SM, Bezem HS, Scott RD, Bierbaum BE, Newberg AH. Bone scanning in the assessment of patellar viability following knee replacement. Clin Orthop. 1985;199:215-9.
96. Figgie HE 3d, Goldberg VM, Figgie MP, Inglis AE, Kelly M, Sobel M. The effect of alignment of the implant on fractures of the patella after condylar total knee arthroplasty. J Bone Joint Surg Am. 1989;71:1031-9.
97. Windsor RE, Scuderi GR, Insall JN. Patellar fractures in total knee arthroplasty. J Arthroplasty. 1989;4(Supplement):S63-S67.
98. D’Hollander A, Burny F, Montery E, Donkerwolcke M. Extraosseous variations of temperature during polymerization of acrylic cement in hip arthroplasties. Acta Orthop Scand. 1976;47:186-8.
99. Willert HG, Ludwig J, Semlitsch M. Reaction of bone to methacrylate after hip arthroplasty. A long-term gross, light microscopic, and scanning electron microscopic study. J Bone Joint Surg Am. 1974;56:1368-82.
100. Orthuera CJ, Berry DJ. Patella fracture after total knee arthroplasty. Read at the Annual Meeting of the American Association of Hip and Knee Surgeons; 1999 Nov 12-14; Dallas, TX.
101. Ritter MA, Campbell ED. Postoperative patellar complications with or without lateral release during total knee arthroplasty. Clin Orthop. 1987;219:163-8.
102. Ritter MA, Herbst SA, Meding JB. Patellofemoral complications following total knee arthroplasty. Effect of a lateral release and sacrifice of the superior lateral geniculate artery. J Arthroplasty. 1996;11:368-72.
103. Le AX, Cameron HU, Otsuka NY, Harrington U, Bhargava M. Fracture of the patella following total knee arthroplasty. Orthopedics. 1999;22:395-8.