Supracondylar Fractures of the Femur

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Abstract

Successful management of the distal femoral fracture is possible with adherence to the basic principles of anatomic reduction, stable fixation, and early motion. Closed management can achieve these goals in selected patients, but most supracondylar femoral fractures are better treated with operative reconstruction. Implant selection is determined on the basis of the characteristics of the fracture, the bone quality, the needs of the patient, and the experience of the surgeon. Surgical options include the angled blade plate, compression-screw systems, condylar buttress plates, intramedullary nails, external fixation, and modular distal femoral replacement. The author reviews the indications and techniques for using these devices.

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Supracondylar femoral fractures occur in the terminal 9 cm of the femur, between the diaphyseal-metaphyseal junction and the femoral condyles. Extension of the fracture into the diaphyseal region is not uncommon in the high-energy injuries frequently experienced by young patients. In elderly patients who sustain distal femoral fractures from minor trauma, such as a simple fall, severe osteopenia and preexisting gonarthrosis may complicate management.

Classification

The AO / ASIF classification designates the supracondylar femoral fracture as type A (Fig. 1).[1] Type A is further divided into subtypes: subtype A1 is a simple fracture; A2, a metaphyseal wedge fracture; and A3, a comminuted metaphyseal fracture. The prognosis for a favorable outcome worsens with progression from subtype A1 to subtype A3.[1]

Nonoperative Management

The goals of management of supracondylar fractures are correction of axial alignment, length, and rotation; restoration of motion; and rapid union so as to return the patient to normal function.[2] In selected cases, closed treatment can accomplish these goals. Early use of a hinged brace may be appropriate for the nondisplaced or impacted supracondylar femoral fracture. Motion can be initiated when pain and swelling have subsided, and ambulation is permitted with toe-touch weight-bearing on the injured side. Frequent radiographic monitoring is necessary to detect fracture angulation or displacement and to assess healing.

When the patient's age or associated medical conditions or injuries preclude operative reconstruction, skeletal traction may be used to treat a displaced supracondylar femoral fracture. A Thomas splint with a Pearson attachment can be combined with skeletal traction achieved with either a single proximal tibial pin or double pins placed in the proximal tibia and distal femur. Active knee motion should be encouraged even while the patient is in traction to prevent intra-articular adhesions and fibrosis. Traction can usually be discontinued at 6 to 8 weeks when the fracture becomes "sticky."[3] To facilitate mobilization, a cast-brace is applied with the patient sedated. Separate full-contact sections are applied to the thigh and to the leg and foot. The thigh section is carefully molded around the condyles, extending well above the level of the fracture. The sections are connected with hinges; radiographs are checked after application; and the cast is wedged as needed to correct positioning. The cast-brace is worn for an additional 6 to 8 weeks and is removed when the patient can tolerate full weight-bearing ambulation.[3]

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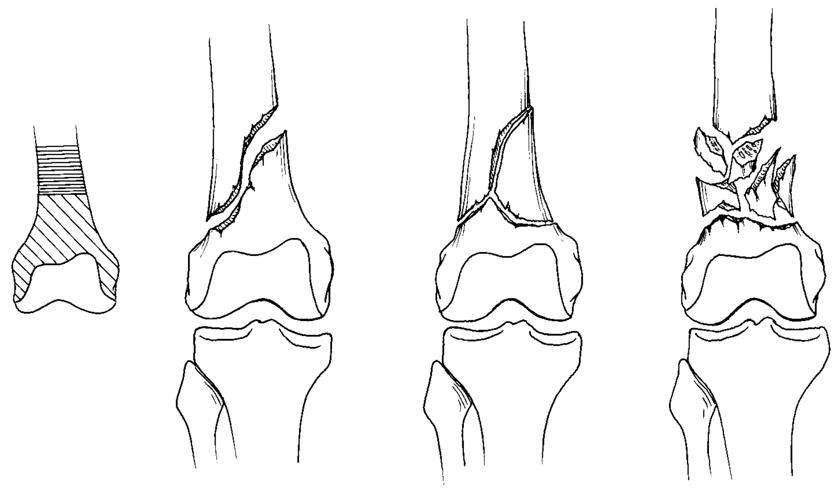

Fig. 1 The AO / ASIF classification of supracondylar (type A) femoral fractures.[1] Subtype A1 is a simple fracture; A2, a metaphyseal wedge fracture; A3, a comminuted metaphyseal fracture.

Surgical Treatment

The surgical treatment of distal femoral fractures follows the basic principles outlined for all complex periarticular injuries.[1] Adequate radiographs are essential for preoperative planning. Careful atraumatic surgical technique is necessary to minimize soft-tissue injury and periosteal stripping. The surgical goals are anatomic alignment and stable fixation of the fracture to allow motion of the limb and early rehabilitation.

Anatomic Considerations

An understanding of the normal anatomy of the distal femur and the axial alignment of the knee joint is a prerequisite to the operative fixation of distal femoral fractures. The mechanical, or weight-bearing, axis of the knee crosses the center of the femoral head and the center of the knee (Fig. 2, A). The mechanical axis differs from the anatomic axis, which has a valgus angulation of 7 to 9 degrees. The knee joint is parallel to the ground.[1]

When the distal femur is viewed with a lateral projection, a line drawn along the posterior cortex bisects the femoral condyles (Fig. 2, B). The anterior half of the condyle is a continuation of the femoral shaft, while the posterior half appears attached to the posterior cortex. This relationship is important when considering appropriate placement of fixation devices, because the blade of an angled blade plate or the lag screw of a compression-screw system must be inserted into the anterior half of the condyles to allow the plate to lie on the femoral shaft.[1]

When viewed in cross section, the distal femur is trapezoidal (Fig. 2, C). The anterior articular surface is not parallel to the posterior cortices of the condyles. The distance measured anteriorly between the medial and lateral walls is less than that measured posteriorly and is less than the maximum distance depicted on a radiograph. This must be considered when determining the correct length of transverse screws.[1]

Indications and Contraindications

Surgical treatment should be considered for all displaced fractures. Indications include open fractures, fractures with associated vascular injury, ipsilateral lower-extremity fractures, fractures in the patient with multiple injuries, irreducible fractures, and pathologic fractures.[4] Fractures associated with disruption of the knee ligaments may require reconstruction of all structures.[4] Even when an anatomic reduction can be accomplished through closed means, operative stabilization should be considered when prolonged immobilization is contraindicated or difficult, as in some elderly or morbidly obese patients.[4]

Relative contraindications to operative fixation include infected fractures, fractures in hemodynamically unstable polytrauma patients, and fractures in very osteopenic bone (e.g., due to preexisting paralysis). Surgery is also contraindicated for a patient with a medical condition that renders anesthetic and operative risks potentially life threatening.[4]

Timing of Surgery

Surgical reconstruction should take place as soon as the appropriate equipment and assistance are available and the patient's condition permits. In the case of a closed fracture, if surgery must be delayed beyond 24 hours, limb length should be maintained with tibial pin traction. Open fractures must be treated urgently by debridement, irrigation, and, if possible, definitive reconstruction, which will facilitate soft-tissue management and patient mobilization. Grossly contaminated fractures may be temporarily stabilized by an external fixator that bridges the fracture site; revision to permanent fixation should be delayed

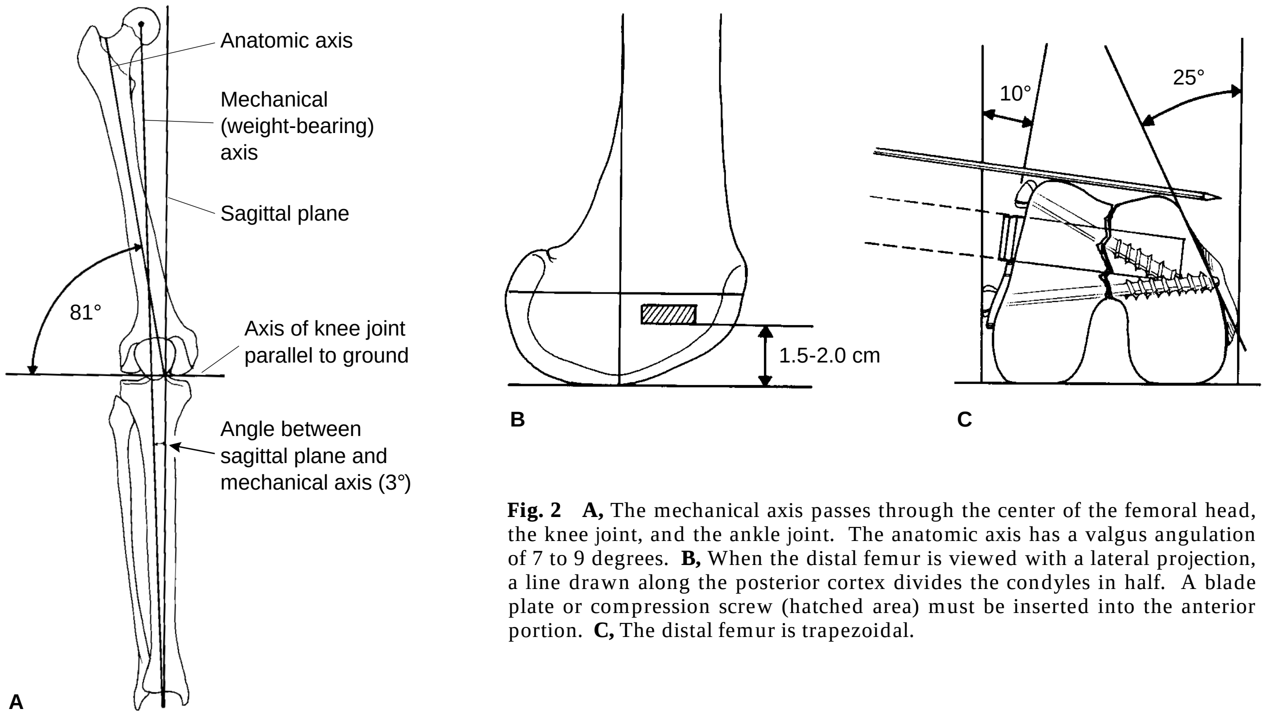

Fig. 2 **A,** The mechanical axis passes through the center of the femoral head, the knee joint, and the ankle joint. The anatomic axis has a valgus angulation of 7 to 9 degrees. **B,** When the distal femur is viewed with a lateral projection, a line drawn along the posterior cortex divides the condyles in half. A blade plate or compression screw (hatched area) must be inserted into the anterior portion. **C,** The distal femur is trapezoidal.

until a clean wound has been obtained through repeated debridement.

Operative Positioning and Approach

I prefer to operate with the patient supine on a radiolucent operating table with a roll placed under the ipsilateral pelvis. The entire lower extremity and the iliac crest are draped free to allow application of a sterile tourniquet.

When open reduction and internal fixation is accomplished with plating techniques, a lateral incision that ends distally between the distal pole of the patella and the tibial tubercle is most commonly used. The vastus lateralis is reflected anteriorly from the lateral intermuscular septum, and the articular surface is visualized by incision of the lateral joint capsule.[1]

The anterolateral approach also provides good exposure of the distal femur. This approach employs the interval between the vastus lateralis and the rectus femoris. It can be extended distally into a lateral parapatellar arthrotomy for access to the knee joint.

The medial approach is used for combined lateral and medial plating of very comminuted fractures. An anteromedial incision begins at the pes anserinus and extends proximally following the adductor canal. The vastus medialis is elevated from the intermuscular septum. As dissection remains anterior to the adductor canal, the superficial femoral artery is not encountered.[5]

Implant Options

Options for the surgical treatment of supracondylar femoral fractures fall into four categories: plates, intramedullary nails, external fixators, and total knee arthroplasty. The selection is determined by the pattern of the fracture, the bone quality, the condition of the patient, and the skill and experience of the surgeon (Table 1).

Angled Blade Plate

The 95-degree angled blade plate is a one-piece, fixed-angle device with a broad, flat blade. The blade plate furnishes the greatest resistance to bending and torsional stresses and produces the most secure fixation of the distal fragment.[1,2] After insertion of the plate into the condyles, indirect fracture reduction is performed by reducing the femoral shaft to the plate to restore the anatomic axis of the femur.[1] Because blade insertion does not necessitate removal of a large amount of bone, very distal supracondylar fractures that extend to within 2 cm of the joint surface can be fixed with this device.[1,6] The blade plate is difficult to use, and meticulous attention to surgical technique is required. Good to excellent results have been reported in 71% to 86%

Table 1
Implant Options

Type of Implant	Relative Indications	Relative Contraindications	Advantages	Disadvantages
Blade plate	Comminuted supracondylar fracture Low fracture	Intracondylar comminution	Strong Able to maintain varus/valgus and antecurvatum or retrocurvatum alignment Most stable fixation	Technically demanding Can comminute unrecognized intracondylar fractures
Compression screw	Comminuted supracondylar fractures associated with simple intra-condylar splits	Intracondylar comminution Very low fractures Coronal fractures	Technically easier to use than blade plate Compresses simple intracondylar splits Able to maintain varus/valgus alignment	More difficult to maintain recurvatum/antecurvatum align-ment in low fractures Occupies a large bone volume in the intra-condylar region Requires additional screw fixation in distal fragment for stability
Condylar plate	Simple supracon-dylar fracture in association with intracondylar comminution	Comminuted supracondylar fracture	Can be contoured to achieve anatomic reduction of a simple fracture Multiple screw insertion can help reduction of intracon-dylar comminution	Poor resistance to varus/valgus moments, so requires reconstruction of medial cortical continuity
Dual plate	Supracondylar and intracondylar comminution	Should be reserved for situations in which no other device will work	Allows multiple-screw fixation of intracon-dylar comminution Dual plates provide strength for supracondylar comminution	Massive dissection with resultant stiffness Potential for “dead bone sandwich”
Antegrade nail	Extensive supra-condylar comminution, especially proximal	Low fractures Intracondylar extension	Minimal dissection and injury of the soft-tissue envelope Strong fixation, automatic grafting (reamings)	Can “blow apart” unrecognized intra-condylar fractures Can be difficult to achieve anatomic alignment
Retrograde nail	Osteoporosis Supracondylar periprosthetic fracture	“High-demand” patient Low fracture	Minimal dissection and injury to soft-tissue envelope Some grafting of the fracture site by reaming	Low-strength device Residual fracture instability may necessitate caution when initiating post-operative motion

of supracondylar femoral fractures treated with blade-plate fixation.[6,7]

The technique for application of the angled blade plate is as follows: A wire is placed parallel to the patellofemoral joint and to the femoral condyles as a guide for blade positioning[1] (Fig. 3, A). Because insertion of the blade plate must be precise in the coronal, sagittal, and axial planes for accurate alignment, the correct position of this guide wire should be verified radiographically. Intraoperative fluoroscopy is helpful in determining guide-wire position and monitoring the insertion of the seating chisel and the blade plate. Before insertion of the chisel, three parallel holes are drilled with use of a triple drill guide and a 4.5-mm drill. The holes are expanded with a router to create a cortical window for the chisel. The seating chisel should be inserted in small increments and backed out a few millimeters each time to prevent incarceration of the chisel or comminution of the condyles. After blade insertion, the femoral shaft is reduced to the plate and fixed with 4.5-mm cortical screws. If no bone defects exist, the fracture is compressed with use of the articulated tensioning device. Aggressive active knee motion should begin after drain removal, and toe-touch weight-bearing should be maintained until the fracture has healed.

Insertion of the angled blade plate is technically demanding, and poor positioning of the blade is difficult to remedy. Improper orientation in the sagittal plane will result in anterior or posterior angulation of the plate off the femoral shaft; therefore, the seating chisel guide must be parallel to the femoral shaft during insertion (Fig. 3, B). Incorrect positioning in the coronal or axial plane will lead to axial malalignment or intra-articular insertion. The positioning of the guide wire must be precise, and chisel insertion must follow the guide wire. Impaction of the seating chisel or blade may result in further or new comminution. Surgeons not experienced in the use of the angled blade plate probably should consider the use of alternative forms of fixation.

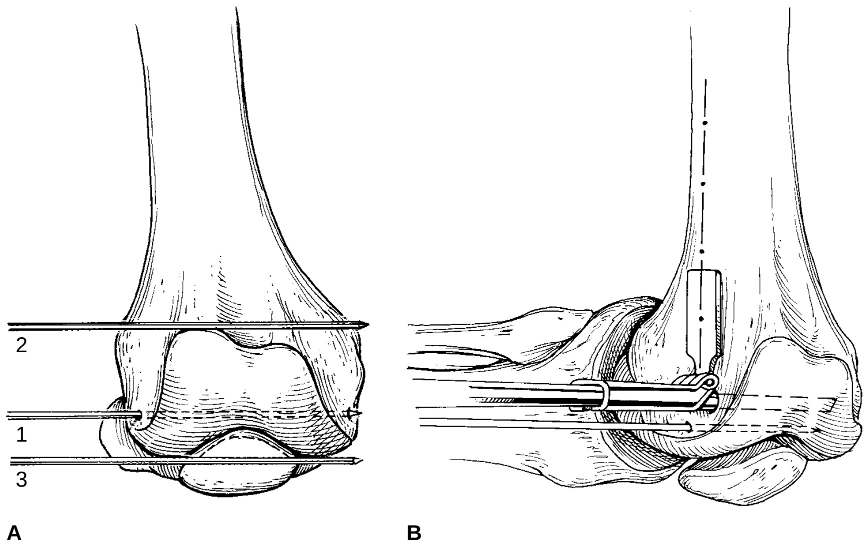

Fig. 3 **A,** The guide wire for blade placement (1) lies parallel to the patellofemoral joint (2) and to the femoral condyles (3). **B,** The seating chisel guide is placed on the femoral shaft to control sagittal-plane placement.

Compression-Screw System

Compression-screw systems are technically easier to use than the angled blade plate. Since sagittal-plane adjustments can be made in plate position, correct orientation is required in only two planes. In addition, the condylar screw provides interfragmentary compression for fractures with an intercondylar split. Sanders et al[8] reported 70% good to excellent results with use of the compression screw and side plate in the treatment of supracondylar and intracondylar fractures. The rates of nonunion and infection were comparable to those reported with fixation with use of the angled blade plate.

The technique for use of the compression-screw system is similar to that for the angled blade plate.[1] A wire guide is placed 2 cm proximal to the joint line, oriented parallel to the condyles and the patellofemoral joint. The wire must be accurately positioned in the coronal and axial planes. The lag screw is inserted after reaming over the guide wire, and the plate is then applied to the lateral aspect of the distal femur.[8]

Although compression-screw systems are suitable for most supracondylar fractures, there are exceptions. Due to the large size of the lag screw, a minimum of 4 cm of intact bone is required in the distal fragment.[8] A 6.5-mm cancellous screw must also be inserted into the distal fragment to gain rotational stability.[1] The compression-screw system is not appropriate for use when there is a low transcondylar fracture, a coronal fracture, or extensive intra-articular comminution. The large lateral shoulder of this device may irritate the iliotibial band and necessitate hardware removal after the fracture has healed.

Condylar Buttress Plate

The condylar buttress plate is a broad plate with a cloverleaf distal portion that is contoured to fit the lateral aspect of the distal femur. It may be used for the fixation of minimally displaced fractures, but is most useful in fractures with articular extension in the sagittal and coronal planes. It can also be used as an intraoperative backup device when difficulties are encountered with the angled blade plate or compression-screw system.

The condylar plate must be correctly positioned with the lateral flare of the plate seated directly over the lateral flare of the condyle. If the plate is placed proximal or distal to the flare, varus or valgus malalignment may occur.[4] Because there is not a rigid interface between the heads of the screws and the plate, instability (unreconstructed comminution) of the medial cortex will allow the screws to shift in the plate, which can result in varus malalignment.[4]

The buttress plate may not provide sufficient fixation for very comminuted fractures with fragmentation of the medial cortex, segmental loss of bone, or a very short distal condylar segment. Without an adequate medial buttress, collapse of the fracture can occur. In this instance, reduction can be maintained with the combined use of medial and lateral plates.[5]

The stability of a fracture fixed with a condylar buttress plate should be assessed intraoperatively by inspecting the interface of the bone and the screw-plate junction for motion during flexion and extension of the knee and during varus and valgus stress of the femur.[5] If residual instability is present, application of a medial plate through a separate medial incision should be considered.

Antegrade Intramedullary Nails

Antegrade interlocked intramedullary nails have been used successfully in the treatment of extra-articular distal femoral fractures when there was 7 cm of intact distal femur or when a 7-cm fragment could be reconstructed with accessory lag screws or distal locking screws.[9] Large-diameter nails should be used to avoid fatigue fracture at the screw holes. When necessary, the intramedullary nail can be shortened to decrease the distance between the distal locking screw and the nail tip. The antegrade locked nail is particularly useful in the treatment of supracondylar fractures with proximal extension into the femoral diaphysis.

Nails should be inserted with the patient supine, because valgus angulation of the distal fragment can occur when the patient is in the lateral position, due to the weight of the leg. The entry portal is contained within the piriformis fossa. Residual angulation of the distal fragment may be corrected with the temporary insertion of Schanz pins into the distal fragment 3 to 4 mm medial and lateral to the trochlear groove and directed toward the femoral notch. These pins are used as joysticks to control the distal fragment during guide-wire insertion, nail insertion, and distal locking.[10] The guide wire must enter the distal fragment in a central position to properly align the condyles with the shaft and should be impacted into the metaphyseal scar before reaming.

Contraindications to antegrade nailing are a preexisting proximal prosthesis or hardware, femoral deformity, obliteration of the intramedullary canal, and insufficient distal bone stock.[11]

Retrograde Intramedullary Nails

The retrograde supracondylar intramedullary nail is a load-sharing device that does not require the extensive soft-tissue dissection needed for plate application. This nail has multiple screw holes, which provide flexibility in the placement of interlocking screws. Successful use of the retrograde nail has been demonstrated in elderly osteopenic patients and in polytrauma patients.[12,13] Additional applications include the fixation of fractures proximal to total knee arthroplasties and fractures distal to proximal femoral implants.[14]

An open or percutaneous surgical approach is selected on the basis of the fracture pattern and the quality of reduction that can be obtained through closed techniques. The patient is positioned supine on a radiolucent table. The knee is flexed to 45 degrees and supported by a leg roll. If an open approach is selected, a midline longitudinal skin incision is made, and a medial parapatellar arthrotomy is performed. The patella is then reflected to expose the nail-entry site in the intercondylar notch, just anterior to the femoral attachment of the posterior cruciate ligament. To ensure correct alignment of the condyles with the shaft, the entry point and subsequent reaming should be aligned with reference only to the condyles. The nail is inserted over a guide wire until the distal end lies flush with the cortex of the intercondylar notch. Through a nail-mounted guide, the distal locking screws are placed first, followed by the proximal screws.[12]

Potential complications of use of the retrograde supracondylar nail include knee sepsis, stiffness, and patellofemoral pain.[13] The stability of fracture fixation is less than that obtained with the blade plate, and residual instability may necessitate caution in initiating postoperative active knee motion. Failure of the nail through the multiple screw holes has occurred; however, newer designs have a closed-section shaft with greater strength and increased fatigue life.

Bridge Plating

The angled blade plate and the compression-screw system can be used for bridge plating of selected supracondylar femoral fractures. Bridge plating is an indirect reduction technique that is appropriate for fractures with a long comminuted metaphyseal segment and an intact soft-tissue envelope.[15] Type A3 supracondylar fractures can be fixed with the bridge-plating technique (Fig. 4).

Ostrum and Geel[16] have described the surgical technique used for bridge plating of supracondylar femoral fractures. Through a lateral approach, the vastus lateralis is elevated from the linea aspera to expose the lateral and anterior aspects of the distal femur. The posterior and medial tissues are not violated. No retractors are placed on the medial supracondylar femur. The choice of implant is determined by the surgeon, and the plate is applied to the distal femur. Indirect reduction of the metaphyseal segment is performed by applying distraction, either manually or with use of a femoral distractor. Length and rotation are determined by direct visualization or by fluoroscopy. The plate is then fixed to the femoral shaft above the level of any medial fracture fragments. No attempt is made to anatomically reduce or fix the comminuted metaphyseal segment.[16]

Failure of fixation does not readily occur because fracture strain is distributed over the entire comminuted segment.[15] It is imperative that the soft-tissue envelope surrounding the metaphyseal segment not be disturbed, so that the vascular supply to the fracture fragments can be preserved. Retractors or bone clamps must not be placed in this region.[15] The bridge plating technique is not appropriate if the soft-tissue envelope is not intact, as in severe open fractures; if marked osteoporosis is present; or if there is significant medial bone loss. Under such circumstances, supplemental fixation of the metaphyseal segment is necessary, and a bone graft should be applied to the medial defect.

External Fixation

External fixation is most frequently considered to be an interim method of stabilization for fractures with extensive soft-tissue damage, fractures in the unstable polytrauma patient, fractures with an associated popliteal artery injury, and fractures in patients with severe burns.[17] When applied for temporary fracture care, the external fixator should bridge the fracture site, and the pins should be placed in the proximal femur and the middle to distal tibia at sites that avoid the surgical field for future reconstructive proce-

A B C D

Fig. 4 Preoperative anteroposterior **(A)** and lateral **(B)** radiographs of a type A3 distal femoral fracture. **C** and **D,** A condylar compression-screw system was used with the bridge-plating technique for indirect reduction and fixation of the fracture.

dures. Complications related to the extended use of standard half-pin fixators include pin-tract and joint-space infection, joint contractures, arthrofibrosis, and malunion.[17]

The indications for use of small-wire or hybrid fixators for definitive fixation of supracondylar fractures are still evolving. Plating techniques and intramedullary nails may not be suitable for supracondylar fractures with a very low transcondylar segment with less than 2 cm of intact bone. With small-wire external fixation, a very short distal segment can be fixed with two or three wires[18] (Fig. 5). Half-pin or thin-wire fixation may be used in the proximal femoral segment. If stability of the distal fragment is questionable, extension of the fixator across the knee may be necessary for a period of 4 to 6 weeks, after which the tibial extension is removed and active knee motion is started.

Because wires placed in a transverse plane passing on either side of the patella traverse the joint capsule, patients must be carefully monitored for pin-tract and knee-joint sepsis. Frames should be large enough to allow for swelling and edema.[18] Extended immobilization may result in limited knee motion. The thin-wire or hybrid fixator offers a treatment option in situations in which no other device is mechanically suitable. However, most supracondylar femoral fractures are well managed with internal fixation devices.

Total Knee Replacement

Supracondylar femoral fractures in elderly persons with very severe osteopenia or preexisting arthrosis pose difficult problems. Internal fixation augmented with methylmethacrylate is one alternative; satisfactory outcomes have been reported in osteopenic patients. When the patient has an arthritic knee, however, persistent pain and stiffness are likely despite successful fracture fixation. One treatment option for some of these patients is distal femoral replacement arthroplasty.[19] Modular replacement arthroplasty may be appropriate for patients with limited treatment expectations, restricted life-styles, limited life expectancy, and severe osteopenia or preexisting gonarthrosis. A total knee arthroplasty addresses both the fracture and the arthritis and provides the most rapid return of function.

The modular hinged prosthesis accommodates varying amounts of bone resection. Freedman et al[19] recommend that the amount of bone resection be calculated preoperatively from scanograms of both lower extremities to ensure equal leg length. The stems of the prosthesis are cemented into the medullary canals to allow immediate postoperative ambulation.

Summary

The management of supracondylar femoral fractures is challenging. Surgical reconstruction is the treatment of choice for most displaced fractures. Selection of the appropriate implant is determined on the basis of the fracture pattern, the condition of the soft tissues, the needs of the patient, and the preference of the surgeon. Restoration of limb length, rotation, and axial alignment, with stable fixation and early motion, can produce uncomplicated fracture healing and a return to normal function for most patients.

A B C D

Fig. 5 **A** and **B,** Hybrid-ring fixation of an open grade IIIB type A3 fracture. **C** and **D,** After fracture healing, patient was ambulatory without external support.

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