The University of Pennsylvania Orthopaedic Journal
12: 57–65, 1999

Retrograde Femoral Rodding

J.C. Alvarez, M.D., William G. DeLong, Jr., M.D., Philip A. Caracciolo, M.P.T., and Christopher T. Born, M.D.

Abstract: Retrograde femoral rodding is a technique that has recently been used with increasing frequency for the management of supracondylar and femoral shaft fractures. A review of the literature reveals that this technique may have advantages over other fixation techniques in certain clinical situations. Retrograde femoral rodding allows the surgeon to treat bilateral lower extremity injuries simultaneously without the use of a fracture table. It has been shown to be a valuable technique in the management of ipsilateral femoral neck and shaft fractures, ipsilateral femoral and pelvic or acetabular fractures, and ipsilateral femoral and tibial fractures. The preferred entry portal, the intercondylar notch, can be reached quickly and effectively by a variety of methods.

There are potential problems with retrograde rodding, specifically, the concern of intra-articular sepsis, synovial metallosis, patellofemoral arthritis, quadriceps atrophy, and knee stiffness. The literature has not verified these concerns. However, more long-term follow-up is needed, particularly for the evaluation of potential patellofemoral arthritis.

This article should assist the surgeon in deciding whether a particular clinical situation merits the use of a retrograde femoral rod. This technique has offered solutions to challenging orthopaedic problems such as ipsilateral femoral neck and shaft fractures. Although long-term follow-up is lacking, the literature reveals that retrograde femoral rodding is a valuable addition to the orthopaedic surgeon's armamentarium for the management of supracondylar and femoral shaft fractures.

Introduction and History

Intramedullary femoral nailing has classically been performed in an antegrade fashion, with a starting point in the piriformis fossa. This antegrade technique has had tremendous success. Winquist et al. [34] had a 99.1% union rate with postoperative knee range of motion averaging 130 degrees and a 0.9% infection rate in a series of 520 femur fractures. Since antegrade rodding has been so successful in treating femur fractures, there has been some resistance to accepting newer techniques. In 1950, Dr. Lezius [17] introduced a form of retrograde femoral rodding to treat subtrochanteric and intertrochanteric femur fractures. A curved nail was introduced through the medial femoral condyle and passed up through the fracture site. In 1970, Küntscher [16] described condylocephalic nailing utilizing a medial femoral condyle starting portal for the management of intertrochanteric hip fractures. Since then, better methods for fixation of subtrochanteric and intertrochanteric femur fractures have been developed. Later, Swiontkowski et al. [32] began treating ipsilateral femoral neck and shaft fractures by stabilizing the femoral neck with multiple cancellous screws, followed by retrograde rodding of the shaft fracture. In this series, the retrograde rods were inserted extra-articularly from a medial femoral condylar starting point. The disadvantage of the medial condylar starting point was that it required the use of a flexible femoral nail or a reversed tibial nail. The tibial nail has no anterior bow and may cause varus malalignment in distal one-third femur fractures. Reversed tibial rods also tend to be smaller in diameter and weaker than larger diameter femoral rods. Subsequently, an intercondylar starting point was developed for retrograde rodding of femoral shaft fractures in order to avoid the varus malalignment associated with the medial femoral condyle starting point [10,24]. Patterson et al. [24] were the first to report on this intercondylar approach after they performed the procedure in 14 patients.

From the Department of Orthopaedic Surgery, University of Pennsylvania School of Medicine, Philadelphia, PA.
Address correspondence to William G. DeLong, Jr., M.D., Department of Orthopaedic Surgery, 3400 Spruce Street, Philadelphia, PA 19104.

Indications for Retrograde Femoral Rodding

Retrograde femoral rodding may have an advantage over other techniques. Specific advantages include decreased setup time in the operating room [21,22]; decreased operative time in certain situations [21,22]; no significant postoperative abductor weakness; no postsurgical heterotopic ossification in the region of the hip; simultaneous treatment of bilateral lower extremity injuries [6,21–24]; effective treatment of ipsilateral femoral shaft and femoral neck fractures [6,10,21–23,32]; no risk of pudendal nerve palsy (which is as high as 17% in antegrade femoral rodding on a fracture table) [2,3,15]; no risk of position-induced well-leg compartment syndrome; rapid access to the intended starting portal in patients with traumatic arthrotomies to the knee [26]; and the ability to treat thoracic and/or abdominal injuries and orthopaedic injuries simultaneously or sequentially without having to change operating tables.

Several authors [6,10,21–23] have advocated retrograde femoral rodding to treat bilateral femur fractures. Both fractures can be rodded simultaneously, thus minimizing operative time and blood loss. Obese patients can be operated on more efficiently and with greater ease using a retrograde technique [5,10,23]. Patients with poor skin quality in the region of antegrade starting points should also be considered candidates for retrograde femoral rodding [6,24]. Ipsilateral femoral neck and shaft fractures can be stabilized using this technique [6,10,21–23,32]. Since there is no direct radiation to the pelvic region during retrograde femoral rodding, pregnant patients may benefit from this technique [6,23,28]. Patients with distorted proximal femoral anatomy, such as patients with Paget's disease or with previous proximal femoral fractures, can present a formidable challenge with an antegrade technique. Therefore, retrograde insertion of a femoral rod may be an attractive alternative [6,29]. Paget's disease tends to distort the proximal femoral anatomy much more than its distal anatomy. Gregory et al. [8] have also demonstrated this technique's usefulness in cases with ipsilateral femoral and tibial fractures (floating knee). In addition, several authors [23,24,28] have expanded its use to cases with ipsilateral pelvic or acetabular fractures Specifically, incisions for antegrade femoral rodding can interfere with subsequent approaches to the acetabulum or pelvis. In addition, the use of a fracture table could potentially stress an unstable pelvis.

Since the reduction forces used in retrograde femoral rodding are less and usually more carefully controlled than the reduction forces used with a fracture table in antegrade femoral rodding, some authors [6] have recommended its use in delayed definitive fixation of the femur after external fixation and vascular repair for grade III open fractures. There are situations in which the traumatic injuries to the patient may make one approach more attractive than another, such as in traumatic knee arthrotomies with femoral shaft fractures and traumatic amputations through the knee [24]. In these cases, the traumatic arthrotomy can provide access to the intercondylar notch. In ipsilateral patella and femur fractures, one approach can allow the surgeon to deal with both injuries if a retrograde approach is chosen. A supracondylar femur fracture in a patient with a hip prosthesis can be managed with a retrograde rod [20]. However, there is the theoretical risk of a stress riser between the prosthesis and the nail [20].

Head-injured patients may also benefit from retrograde femoral nailing. An antegrade approach in a patient with a head injury can lead to significant heterotopic ossification in the region of the hip joint [4,24,31]. Lonner et al. [18] described the use of a retrograde femoral rod in a patient with an ankylosed hip and stiff knee with a prior history of head injury. The patient had significant heterotopic ossification about the hip and sustained a femoral shaft fracture after a fall. The presence of heterotopic ossification in the hip region preoperatively made an antegrade starting portal almost impossible. The authors proceeded with retrograde femoral nailing and obtained good results.

Disadvantages of Retrograde Rodding

Retrograde femoral rodding may also have some disadvantages. When the retrograde rod was introduced, concern for the development of post-traumatic arthritis with an intra-articular starting point caused the orthopaedic community to utilize an extra-articular starting point on the medial femoral condyle [16,17,21]. This starting point, however, has been associated with varus malalignment [24]. An intercondylar notch starting portal was subsequently developed, again raising concerns about patellofemoral arthrosis [12,24]. Additional disadvantages may include the potential for knee stiffness, quadriceps atrophy, risk of intra-articular sepsis, risk of synovial metallosis [14], and the need for an arthrotomy if the hardware is removed [10,24].

Technically, it is usually more difficult to judge rotational alignment and achieve proper length during retrograde femoral rodding. Therefore, the surgeon needs to be cognizant of this potential problem [33]. The proximal interlocking screw in retrograde femoral rods can be challenging because of the amount of soft tissue in the region of the proximal thigh. Loss of the screw in the thigh can be a technical nightmare. There is no accurate targeting device for this interlocking screw hole in retrograde femoral rods intended for femoral shaft fractures.

Earlier designs of some retrograde rods, specifically the GSH nail for supracondylar femur fractures, had some biomechanical shortcomings. The original GSH nail came in 11 and 12-mm diameters with 6.4-mm interlocking screw holes throughout the length of the rod [6]. Delong and Bennett [6] treated a series of 41 supracondylar femur fractures with a retrograde GSH nail. They had five delayed unions and four nonunions. All of the nonunions were associated with fatigue fractures through an empty interlocking screw hole in the middle of the GSH supracondylar nail. These occurred with the 11-mm diameter nails. The GSH nail has been subsequently modified to 12 and 13-mm diameters with 5-mm interlocking screws to decrease the incidence of this complication. The GSH nail's modification has increased its fatigue life by a factor of five in laboratory tests [30]. Only one fatigue failure has occurred since the nail's modification. However, since there was one failure despite the previous modification, further changes have been made, specifically the elimination of the intermediate screw holes in the central portion of the nail. This technological advancement should eradicate concerns over the biomechanical strength of these supracondylar rods.

Review of the Literature

Retrograde femoral rodding has not been in use as long as antegrade femoral rodding and, hence, has not stood the test of time. However, it should be noted that a confounding variable in the majority of cases reported in the retrograde femoral rodding literature is that the severity of the injury is usually of greater magnitude than that encountered in patients who underwent antegrade femoral rodding. Winquist et al. [34] reported a series of 520 femur fractures. Seventeen percent of these fractures were open. In contrast, Iannacone et al. [11] reported a series of 41 supracondylar fractures, 22 (54%) of which were AO type C open fractures (Table 1). Moed and Watson [21] reported that of 22 femoral shaft fractures in their first series, 32% were open. Moed et al. [22] published a second series of 35 femur fractures, which included broader criteria for retrograde femoral nailing. Only 11 of these were open fractures. This second series had a patient population that was similar to the patients included in the antegrade femoral rodding literature.

Interestingly, as the patients became more similar so did the results of the studies. Moed et al.'s [22] union rate jumped from 86% in their first series to 94% in the second series, approaching the 99.1% union rate established by Winquist et al. [34]. It should be noted that Moed et al.'s protocol in the second series included planned dynamization in statically locked stable fractures and in unstable fractures that show minimal healing at 6–12 weeks.

At the 1998 annual meeting of the Orthopaedic Trauma Association, two prospective studies on retrograde femoral rodding were presented. Ostrum et al. [23] presented a series of 100 femur fractures that were treated by either antegrade or retrograde femoral rodding. They found no significant difference in postoperative knee range of motion between the antegrade and retrograde groups. Full ipsilateral knee range of motion was achieved in 63.6% of the antegrade group and in 72.3% of the retrograde group. However, the antegrade group achieved full knee range of motion quicker than the retrograde group, averaging 8.7 weeks versus 14.6 weeks in the retrograde group. The authors concluded that this difference was related to the increased amount of associated knee pathology in the retrograde group preoperatively. The union rate for retrograde nailing was lower in this series, 89% versus 100% for antegrade rodding.

Tornetta and Tiburzi [33] presented a series of 38 antegrade femoral nailings and 31 retrograde nailings. They found no difference in knee or hip range of motion between the groups. However, they had a higher incidence of malreductions in the retrograde group. They concluded that achieving length and judging rotation is more difficult without a fracture table. Therefore, one should be very cognizant of achieving proper length and rotation when using a retrograde femoral rod.

Ricci et al. [25] presented a series of 359 femur fractures, 175 treated with antegrade femoral nailing and 166 managed using a retrograde technique. The malreduction rate was 0–3% for both groups. They concluded that both antegrade and retrograde rodding can lead to excellent fracture reduction and alignment for femoral midshaft fractures However, retrograde nailing proved to be superior in the reduction and alignment of distal femoral fractures when compared to antegrade nailing.

Table 1. 41 Supracondylar femur fractures

	Number	Percentage
Open*	22	54%
Healed in 4 months	32	78%
Knee range of motion >90 degrees	36	88%
Delayed unions	5	12%
Nonunions†	4	9.7%

*Fifty-four percent of the open fractures were AO type C.
†All the nonunions were associated with fatigue fractures of the supracondylar nail through the unused 6.4-mm interlocking screws holes in the middle portion of the original 11 and 12-mm GSH nails. The current GSH nail has an increased diameter (12 and 13 mm), increased wall thickness, and 5-mm diameter interlocking screw holes. This has resulted in a fivefold increase in the nail's fatigue life in laboratory testing [30] and a much lower rate of clinical fatigue fractures.
(Data from Iannacone et al. [11].)

There has always been a concern for potential patellofemoral arthritis with an intra-articular starting portal [12,24]. To date, there has not been enough long-term follow-up to determine whether this should truly be a concern. Some authors have argued that retrograde nailing probably does not lead to significant posttraumatic arthritis because the intercondylar starting point is not in a weight-bearing area and is brought into contact with the patella only in extreme flexion [24]. Moed and Watson [21] had 6 patients in their series of 22 fractures that complained of continued knee pain postoperatively. Arthroscopy was performed in three of these patients approximately 6 months after femoral fixation. Arthroscopy revealed no abnormalities except for some scarring in a patient who had a history of an ipsilateral patellar dislocation. Moed and Watson [21] also performed exchange nailing in two of the six patients, allowing close inspection of the knee joint after previous retrograde femoral nail insertion. Inspection of the joint once again revealed no pathologic changes. The intercondylar entry portal was actually covered by fibrous tissue. Biopsy of this tissue revealed that it was fibrocartilage [21]. In Moed et al.'s second series of 35 femoral shaft fractures treated with retrograde rodding, they exchanged a nail to prevent infection in a quadriplegic patient who developed a decubitus ulcer. Inspection of the joint at that time again showed no intra-articular pathology and an intercondylar notch portal that was completely covered by fibrous tissue [22].

Postoperative knee stiffness is another potential concern with retrograde femoral rodding. However, several studies [6,8,10,21–24,26,32] have shown that knee range of motion is not adversely affected by this technique The risk of intra-articular infection and metallosis [14] has also been mentioned in the literature as a potential problem. Ironically, the alternative fixation used for supracondylar femur fractures such as a 95 degree screw and side plate, a 95 degree blade plate, or a condylar buttress plate is also in an intra-articular location. Therefore, it can be hypothesized that a retrograde rod does not have an increased risk of infection or metallosis when compared to traditional supracondylar femoral fracture fixation.

The issue of quadriceps atrophy and weakness is another potential pitfall of retrograde rodding. In Moed et al.'s most recent series [22], only 2 of 31 ambulatory patients (four patients were nonambulatory secondary to either closed head injury or spinal cord injury) demonstrated mild quadriceps weakness. One of the two patients had a limp with prolonged walking. Both patients were responding to exercise therapy at their latest follow-up. In Herscovici and Whiteman's series of 45 fractures [10], eight patients had decreased strength in the affected leg. Six of these patients had full motor strength but a mild difference that could be appreciated when comparison was made to the unaffected leg. Two of the eight patients lost a full grade of strength. This loss of strength was attributable to reflex sympathetic dystrophy in one patient and to multiple traumatic knee injuries in the other patient. Although loss of quadriceps strength is a concern, the literature reveals that it is usually mild and responsive to exercise therapy [22]. Overall, patients treated with a retrograde technique have a low incidence of limping and pain [22]. Although antegrade nailing has been considered a relatively benign procedure, Bain et al. [1] have shown that it is associated with trochanteric pain, thigh pain, stiffness, abductor weakness, limp, reduced walking distance, and difficulty with stair climbing. Trochanteric pain is the most common complaint (40%) [1].

Description of Operative Technique

The patient is positioned supine on a radiolucent table. The surgeon must then decide which entry portal will be used to pass the intramedullary rod. The intercondylar starting point (Fig. 1A) is used more often because there is less likelihood of varus malreduction when compared to the medial femoral condyle entry portal (Fig. 1B). The optimal starting point for this portal is in the intercondylar notch one finger breadth anterior to the posterior cruciate ligament origin, similar to the location where a femoral intramedullary guide rod would be placed during a total knee replacement [24].

There are at least four ways to approach the intercondylar starting portal. The first method is to do a medial parapatellar arthrotomy as in total knee arthroplasty. This approach is advised if there is an intra-articular fracture component requiring reduction and fixation [6,24]. This is the approach initially used by Herscovici and Whiteman [10] in their series. However, later in the series, they used a modified percutaneous technique. An incision of about 7 cm is made from the inferior border of the patella to the superior border of the tibial tubercle. The patellar tendon is retracted laterally and the posterior cruciate ligament is visualized and palpated. A guide pin is inserted in the notch 1 cm anterior to the ligament. Fluoroscopy is then used to verify the position of the pin, which should lie in the center of the femur between the anterior and posterior cortices on the lateral view. The pin is advanced 10 cm and a reamer is passed over the guide pin, establishing the entry portal. The surgeon should be careful to avoid any contact between the reamer and the articular surface of the patella.

Moed and Watson [21] also describe a modified percutaneous technique. An incision is made from the inferior patellar border to the superior border of the tibial tubercle. The patellar tendon is split longitudinally in its midline. A guide pin is placed approximately 1 cm anterior to the posterior cruciate ligament. After fluoroscopic verification, the pin is advanced. A cannulated step-drill is passed over the guide pin to establish the entry portal. The surgeon can also take advantage of traumatic arthrotomies or other clean wounds over the knee to quickly establish an entry portal for the rod [24]. Some authors have also described an arthroscopic technique for making the starting portal for retrograde femoral rods.

After the entry portal is established, further specific steps vary, depending on the fracture type, presence of associated injuries, and surgeon preference. Retrograde supracondylar nails can be used for almost any supracondylar femur fracture (Fig. 2). The only major limitation is that the medial and lateral epicondylar cortices must be able to allow secure bicortical fixation with at least two distal interlocking screws [6]. Comminution of these cortices should be repaired with screws prior to passing a retrograde nail [6,9]. If the cortices cannot be restored, a condylar buttress plate or similar device would be a better option [6]. The supracon-

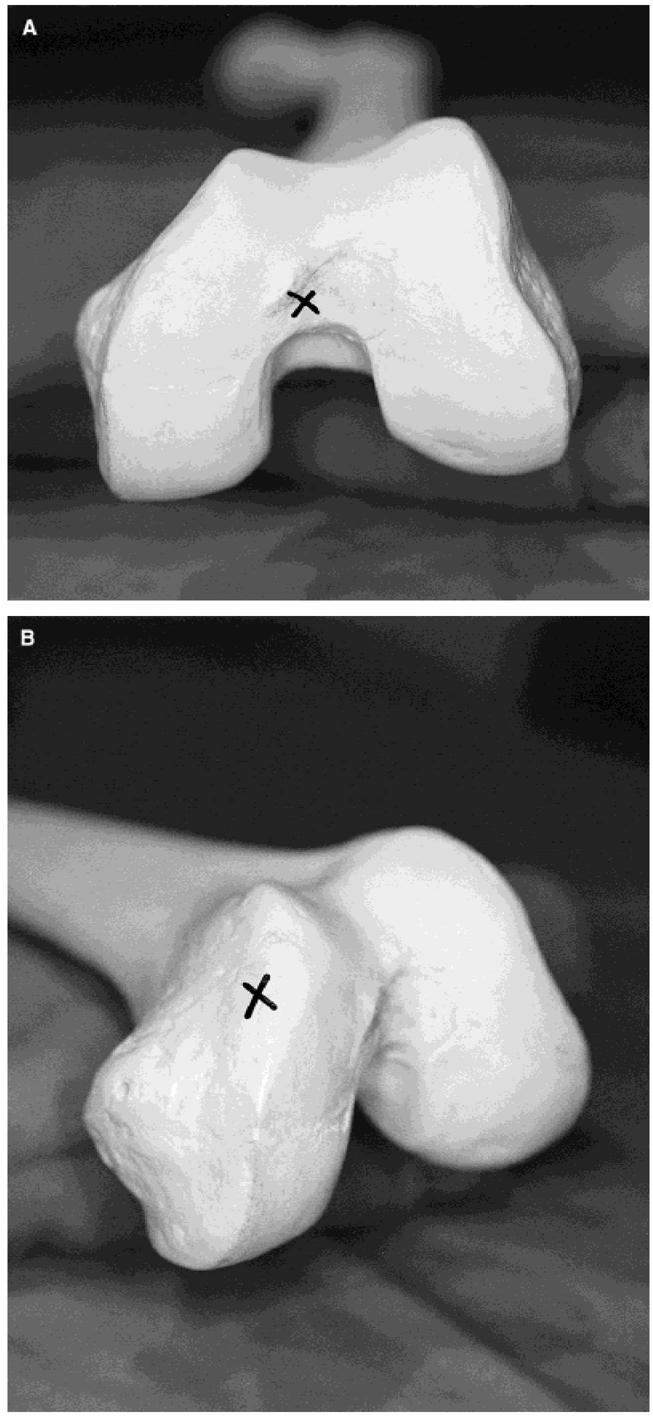

Fig. 1. A: Demonstration of the intracondylar starting portal. **B:** Location of the medial starting portal.

Fig. 2. An example of a supracondylar femur fracture with intercondylar extension. The fracture was treated with open reduction and internal fixation of the condyles followed by retrograde insertion of a GSH nail. (Radiographs courtesy of J.H. Lonner, M.D.)


A
B
C
R
74
D
R
74

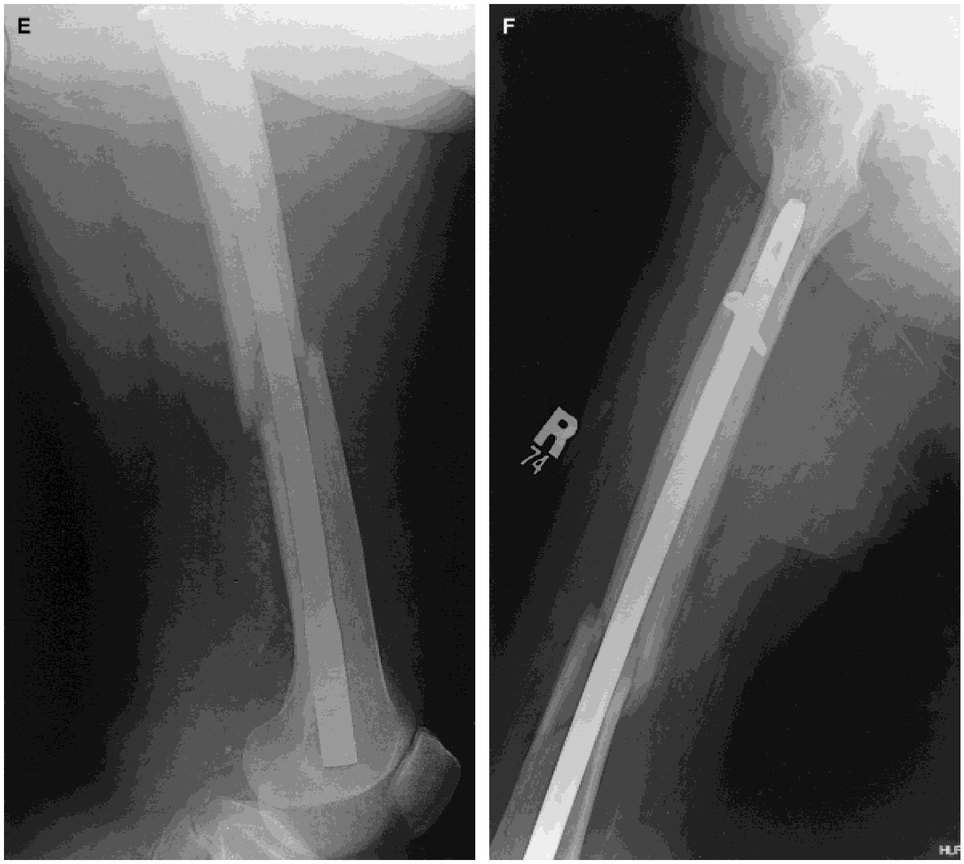

Fig. 3. An example of a femoral midshaft fracture treated with a retrograde femoral rod. (Radiographs courtesy of J. H. Lonner, M.D.)

dylar nail (GSH nail) has a maximum length of 300 mm with a lateral targeting device that is effective up to 250 mm. The GSH nail can be used for fractures that are within 20 cm from the distal end of the femur [6]. In the event that a fracture extends more proximally, a retrograde femoral nail intended for the femoral shaft can be used.

Retrograde Rodding of Supracondylar Fractures

Once the surgeon has decided that a supracondylar femur fracture can be managed with a retrograde technique, the entry portal can be made by one of the methods described earlier. However, it should be emphasized that greater exposure, such as a medial parapatellar approach, is recommended in situations with intra-articular comminution [6,13,24]. The articular component of the fracture must be reduced and fixed with screws. The screws must be placed so that they do not interfere with nail passage. The guide wire is placed in the entry portal, and any extra-articular component of the fracture is reduced and the guide wire passed across the fracture site. There are several ways to achieve a reduction. The most simple is manual traction and the application of correctional forces that vary depending on the fracture pattern. If difficulty is encountered with the reduction, the surgeon may pass a drill sleeve over the guide wire and into the distal fragment. The drill sleeve can then be used to "joystick" the distal fragment into place [6]. If this maneuver fails, a femoral distractor may be used. The distractor must be positioned so that it will not impede nail passage or interfere with the lateral targeting device [6]. Once the fracture is reduced and the guide wire is across the fracture, the canal can be reamed incrementally to 1–2 mm wider than the anticipated nail width [6]. In cases with articular involvement fixed with screws, one should also hold the reduction with two to three large reduction clamps and observe the fracture sites closely while reaming to assure that displacement does not occur. The bulb-tipped guide wire is then exchanged for a smooth guide wire using an exchange tube. The nail with its lateral targeting device is passed up the medullary canal [6]. It is vital that the distal end of the nail be buried at least 2 mm deep to the subchondral bone [6]. These supracondylar nails should be statically locked with at least two distal and two proximal screws [6,19]. One proximal screw may be used if the rod has at least 10 cm of secure intramedullary purchase [6].

Retrograde Rodding of Femoral Shaft Fractures

The technique for retrograde rodding of femoral shaft fractures is similar to that of the supracondylar rod (Fig. 3). The same starting portal is used. The approach varies according to the type of fracture, condition of the soft tissues, presence or absence of associated injuries, and surgeon preference. The nail should be countersunk at least 2 mm below the subchondral bone of the knee and should extend to the lesser trochanter. If the nail is dynamized or there is a possibility of dynamization in the future, it is recommended that the nail be countersunk 1 cm below the articular surface [21]. Fractures that extend proximally to within 5 cm of the lesser trochanter cannot be treated with this technique and a different form of fixation must be chosen.

Once an entry portal is established, either by drilling over a guide wire or by using an awl, a guide wire is placed in the medullary canal. The fracture is reduced using a variety of methods. Manual reduction can be attempted. Steinmann pins can be placed in the distal fragment, using the posterior condyles to assist with the reduction [10]. If difficulty is encountered, a femoral distractor may be used [21,22]. Once again, care must be taken to prevent the device from interfering with rod advancement. The greater trochanter and posterior femoral condyles are good locations for placement of the Steinmann pins when using a femoral distractor. A sterile tourniquet can also facilitate a reduction [10]. In order to use the tourniquet reduction technique, manual traction should be applied to bring the fracture out to length. Once length is achieved, the tourniquet, which is placed over the fracture site, is inflated [10]. If the surgeon wants to ream the medullary canal, a guide wire is passed across the reduced fracture site. If an unreamed nail is chosen, the nail may be advanced immediately after the reduction is achieved. Interestingly, in some instances the rod itself can facilitate the reduction by providing a lever on the distal fragment during rod insertion [21].

The depth to which the nail is buried depends on whether the nail is dynamized or if future dynamization is a possibility. Moed et al. [22] recommend recessing the nail 10 mm if it is or potentially will be dynamized. The distal interlocking screws usually have a targeting device that can be used for drilling and placing the screws. However, the proximal interlocking screw requires the use of free-hand techniques and is usually an anterior-posterior screw.

The proximal interlocking screw can be technically challenging because of the amount of soft tissue surrounding the proximal femur and the proximity of neurovascular structures in that area. To facilitate placement of the proximal interlocking screw, one may use a generous incision. A 3-cm incision can be made anteriorly on the thigh over the site of the proximal interlocking hole. The fascia can then be incised and blunt dissection carried down to the femur. The anterior, medial, and lateral cortices can be felt and the surgeon can proceed to make the proximal drill hole with perfect circle free-hand technique. When passing the screw, an absorbable suture tied around the screw can prevent loss of the screw in the soft tissues.

Postoperative Rehabilitation

Knee surgery has traditionally been divided into two categories: trauma and elective procedures. Although the literature for elective knee surgery rehabilitation is abundant, the literature for procedures performed for traumatic knee injuries is sparse. However, many of the techniques used for the rehabilitation of elective knee surgeries have been adopted by orthopaedic traumatologists and physical therapists that deal with knee trauma. Desired results can be more readily attained if the orthopaedic surgeon and physical therapist utilize sound biomechanical principles that will not disrupt the healing process.

Mobilization of patients with supracondylar or femoral shaft fractures treated with retrograde rodding can be progressed as follows, provided the fracture is well fixed. Range of motion is started early in fractures with stable retrograde fixation. A continuous passive motion machine can be utilized [7,27]. Active-assisted and active range of motion exercises in the unloaded position, such as heel-slides or seated flexion and extension, can also be valuable adjuvants for achieving range of motion. Aggressive passive range of motion is avoided in the postoperative period until fracture healing is achieved, since it can disrupt the fracture site.

The patient's strength training can be progressed from submaximal isometric exercises to limited arc isometric exercises. The patient can gradually advance to open chain exercises. In open chain exercises, the foot is allowed to move freely, promoting both neuromuscular control and strength [7]. These open chain exercises are progressed as tolerated, provided the fracture site is stable. Closed chain exercises, which require the foot to be in a loaded or weight-bearing position, are initiated once fracture healing is noted and weight-bearing status is improved.

The course of recovery varies from patient to patient. Moderate strength gains can be expected from 6 to 12 weeks into the postoperative period. A patient who displays normal progress can anticipate an approximately 80% improvement within 4–6 months postoperatively.

Summary

Although it is a relatively new technique, retrograde femoral nailing has been a valuable addition to the orthopaedic surgeon's arsenal for the management of supracondylar and femoral shaft fractures. The technique offers advantages over antegrade nailing in certain clinical situations. It allows the surgeon to treat bilateral lower extremity injuries simultaneously, minimizing operative time. The approach to the preferred entry portal, the intercondylar notch, can be reached quickly and with minimal dissection. There are potential problems with retrograde rodding, specifically, the potential for patellofemoral arthritis, knee stiffness, quadriceps atrophy, synovial metallosis, and intra-articular infection. The literature has not shown an increased incidence of these complications in these patients. However, more long-term follow-up is needed, especially for the evaluation of potential patellofemoral arthrosis.

References

1. Bain G, Zacest A, Paterson D, et al: Abduction strength following intramedullary nailing of the femur. *J Orthop Trauma* 11:93–97, 1997.
2. Brumback RJ, Ellison TS, Molligan H, et al: Pudendal nerve palsy complicating intramedullary nailing of the femur. *J Bone Joint Surg* 74A:1450–1455, 1992.
3. Brumback RJ, Lakatos R, Poka A, et al: Pudendal nerve palsy com-

plicating intramedullary nailing of the fractured femur. *Orthop Trans* 12:721, 1988.

4. Brumback R, Wells D, Lakatoss R, et al: Heterotopic ossification about the hip after intramedullary rodding for fractures of the femur. *J Bone Joint Surg* 72A:1067–1073, 1990.
5. Buckwalter JA and Cruess RL: Healing of the musculoskeletal tissues. In: Rockwood et al (eds). *Rockwood & Green's Fractures in Adults.* Philadelphia: Lippincott, pp 181–185, 1991.
6. DeLong WG and Bennett FS: The GSH supracondylar nail. In: ??? (eds). *The Science and Practice of Intramedullary Nailing* (2nd ed.). Media, PA: Williams and Wilkins, 1997.
7. Ganz SB: Physical therapy of the knee. In: Insall JN (ed). *Surgery of the Knee.* New York: Churchill Livingstone, pp 1171–1191, 1993.
8. Gregory P, DiCicco J, Karpik K, et al: Ipsilateral fractures of the femur and tibia: Treatment with retrograde femoral nailing and unreamed tibial nailing. *J Orthop Trauma* 10:309–316, 1996.
9. Henry SL, Trager S, Green S, et al: Management of supracondylar fractures of the femur with the GSH intramedullary nail: Preliminary report. *Contem Ortho* 22:631–640, 1991.
10. Herscovici D and Whiteman KW: Retrograde nailing of the femur using an intercondylar approach. *Clin Orthop* 332: 98–104, 1996.
11. Iannacone WM, Bennett FS, DeLong WG, et al: Initial experience with the treatment of supracondylar femoral fractures using the supracondylar intramedullary nail: A preliminary report. *J Orthop Trauma* 8:322–327, 1994.
12. Insall JN and Kelly MA: Fractures of femoral condyles. In: Insall JN (ed). *Surgery of the Knee.* New York: Churchill Livingstone, p 1017.
13. Janzing HMJ, Stockman B, Van Damme G, et al: The retrograde intramedullary nail: Prospective experience in patients older than sixty-five years. *J Orthop Trauma* 112:330–333, 1998.
14. Johnson E, Marroquin C, Kossovosky N: Synovial metalllosis resulting from intraarticular intramedullary nailing of a distal femoral nonunion. *J Orthop Trauma* 7:320–324, 1993.
15. Kao JT, Burton D, Comstock C, et al: Pudendal nerve palsy after femoral intramedullary nailing. *Orthop Trans* 15:836, 1991.
16. Kuntscher GA: New method of treatment of peritrochanteric fractures. *Proc R Soc Med* 63:1120–1121, 1970.
17. Lezius A: Intramedullary nailing of intratrochanteric and subtrochanteric fractures with a curved nail. *J Int College Surg* 13:569–572, 1950.
18. Lonner BS, Lonner JH, Sadler AH: Retrograde femoral nailing between an ankylosed hip and a stiff knee. *J Orthop Trauma* 9:266–269, 1995.
19. Lucas SE, Seligson D, Henry SL: Intramedullary supracondylar nailing of femoral fractures. A preliminary report of the GSH supracondylar nail. *Clin Orthop* 296:200–206, 1993.
20. Menth-Chiari WA, Wozasek GE, Vecsei V: Retrograde nailing of supracondylar femoral fractures in patients with total hip arthroplasty: A preliminary report. *J Trauma* 41:1059–1063, 1996.
21. Moed BR and Watson JT: Retrograde intramedullary nailing, without reaming, of fractures of the femoral shaft in multiply injured patients. *J Bone Joint Surg* 77A: 1520–1527, 1995.
22. Moed BR, Watson JT, Cramer KE, et al: Unreamed retrograde intramedullary nailing of fractures of the femoral shaft. *J Orthop Trauma* 12:334–342, 1998.
23. Ostrum RF, Agarwal A, Lakatos R, et al: A prospective comparison of antegrade and retrograde femoral intramedullary nailing. *Presented at the Orthopaedic Trauma Association Annual Meeting,* Vancouver, British Columbia, Canada, 1998.
24. Patterson BM, Routt ML, Benirschke SK, et al: Retrograde nailing of femoral shaft fractures. *J Trauma* 38:38–43, 1995.
25. Ricci WM, Bellabarba C, O'Boyle M, et al: Retrograde vs. antegrade nailing of femoral shaft fractures. *Presented at the Orthopaedic Trauma Association Annual Meeting,* Vancouver, British Columbia, Canada, 1998.
26. Rodgers WB, Kennedy JG, Coran DL, et al: Retrograde intramedullary nailing of the femur using a tibial nail: The adjunctive use of an existing implant — A case report. *Bull Hosp Jt Dis Orthop Inst* 55: 78–80, 1996.
27. Salter RB, Simmons DF, Ma: The biological effect of continuous passive motion on healing of full thickness defects in articular cartilage. *J Bone Joint* 62A:1232–1251, 1980.
28. Sanders R, Koval KJ, DiPasquale T, et al: Retrograde reamed femoral nailing. *J Orthop Trauma* 7:293–302, 1993.
29. Sinha AK and Mani GV: Retrograde nailing for distal femoral fractures in Paget's disease. *Injury* 27:514–515, 1996.
30. Smith & Nephew Richards, Inc.: Fatigue testing of the supracondylar nail. Technical Report O.R.: 92–122, Memphis, TN.
31. Steinberg G and Hubbard C: Heterotopic ossification after intramedullary rodding. *J Orthop Trauma* 7:536–542, 1993.
32. Swiontkowski MF, Hansen ST, Kellam J: Ipsilateral fractures of femoral neck and shaft. A treatment protocol. *J Bone Joint Surg* 66A:260–268, 1984.
33. Tornetta P and Tiburzi D: Anterograde vs. retrograde reamed femoral nailing: A prospective randomized trial. *Presented at the Orthopaedic Trauma Association Annual Meeting,* Vancouver, British Columbia, Canada, 1998.
34. Winquist R, Hansen S, Clawson K: Closed intramedullary nailing of femoral fractures. *J Bone Joint* 66A:529–539, 1984.