Nailing of Proximal and Distal Fractures of the Femur: Limitations and Techniques

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Summary: Over the last 15 years, a continual evolution of nail design and techniques has made nailing at the extremes of the femur more commonplace. This evolution has yielded a better understanding and ability to control fractures of the metaphysis and, in the distal femur, even intra-articular fractures. With understanding of common pitfalls and reduction techniques, uneventful healing with anatomic alignment, rotation, and length can be achieved with nails at both far proximal and far distal fractures of the femur.

Key Words: distal femur fracture, intertrochanteric fracture, intramedullary nailing, retrograde femoral nail, subtrochanteric fracture

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INTRODUCTION

Nailing at the extremes of the femur is becoming more commonplace. Experience, nail design, and evolving reduction techniques all have contributed to proximal femoral fractures being managed increasingly by intramedullary devices. Although femoral neck fractures are not currently managed by nails, subtrochanteric and intertrochanteric injuries are increasingly being managed by nails in trauma centers. There is little doubt that anatomically precontoured, fracture-specific plates will continue to evolve and remain part of the armamentarium of the fracture surgeon. Currently, however, management with intramedullary techniques may have advantages regarding time until weight bearing, blood loss, etc. Similarly, in the distal femur, nailing of extremely distal fractures with and without intra-articular extension is also becoming more commonplace as experience, implants, and reduction techniques improve. This discussion aims to address some specific limitations and techniques to nailing in both proximal and distal fractures.

PROXIMAL FRACTURES

Intertrochanteric Fractures

For intertrochanteric fractures, reduction of fracture fragments can usually be achieved by closed means with the aid of a fracture table. Malalignment (posterior sag) of complex 4-part intertrochanteric fractures is often underappreciated and may contribute to more complicated nailing of these fractures. Uncorrected posterior sag may lead to noncollinear placement of the lag screw, which puts the lateral trochanteric wall at risk for iatrogenic fracture.[1] Although iatrogenic fracture of the lateral wall is of less concern with nails than with plates, one should still make efforts to avoid this complication.

If posterior sag is recognized, one can use reduction aids to make nailing easier. The malalignment can be corrected by a number of techniques. A crutch or similar device is useful but often is cumbersome and may limit fluoroscopic access. Reduction devices that connect to fracture tables are available (Figs. 1A–C). Posterior sag may be corrected intraoperatively during nail insertion by lifting on the insertion handle to correct sag. Successful application of such intraoperative techniques requires experience as they may require maintaining fragment reduction during guidewire insertion, reaming, and placement of neck–head hardware.

Subtrochanteric Fractures

The common deformities of the proximal femur after subtrochanteric fracture are as follows: abduction from gluteus medius/minimus, flexion/external rotation from the iliopsoas (if lesser trochanter intact), and adduction/shortening of the distal fragment by the hamstrings/adductors.[2] Appreciation of these deformities is the basis for rational fixation of subtrochanteric fractures.

Correcting length requires a fracture table and muscle paralysis and is usually easily accomplished. Common errors arise from accepting residual external rotation and flexion of the proximal segment. This is often manifested on the lateral radiograph with the classic flexion of the proximal fragment. If nailing proceeds in this position, the nailing results in a fixed malreduction, with the proximal fragment externally rotated and flexed. One common misconception is that the nail will reduce the fracture upon entry. Unless blocking screws are used after reaming a malreduction, the position of the fracture will not change. This type of nail malreduction is best avoided by achieving acceptable anatomic reduction before reaming and nail insertion. A proximal fragment "joystick" will allow the surgeon to correct external rotation and flexion, and the reduction can be further improved by utilizing a ball spike pusher on the proximal fragment to correct flexion and abduction.[3] The reduced position must be maintained for the remainder of the procedure until the nail is in place.

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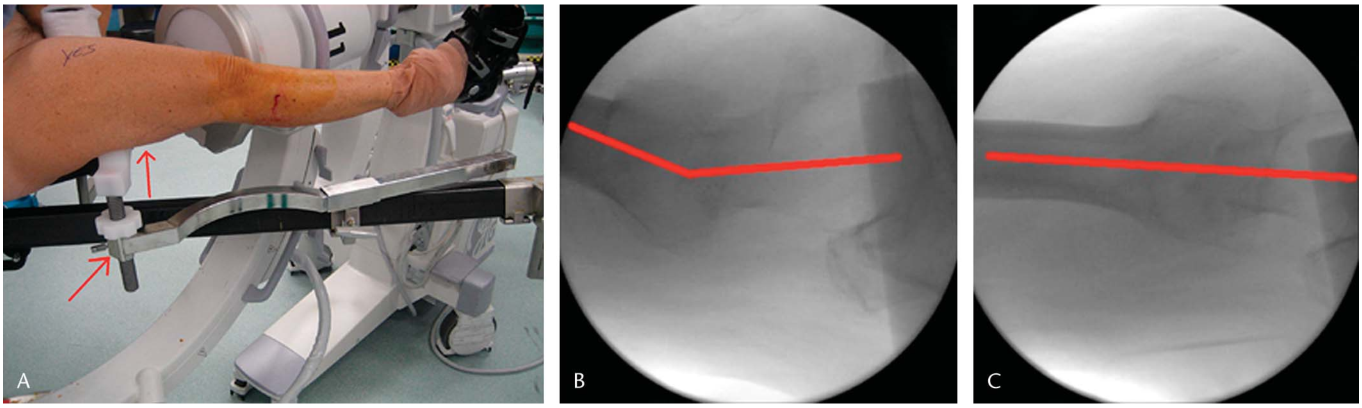

FIGURE 1. A, PORD (Orthofix, McKinney, TX) attached to fracture table and applies lift. B, Posterior sag of an intertrochanteric fracture prereduction. C, After application of the posterior reduction device, the posterior sag is corrected.

Reduction of subtrochanteric fractures may be achieved by open reduction and clamping. Usually, the level of the subtrochanteric fracture correlates with the incision needed to place the lag screw/blade. By making the lag screw incision slightly larger, direct access/reduction is possible. Uneventful union will result if access, reduction, and temporary fixation/clamping are accomplished with minimum medial stripping in a biologically "friendly" method. There is evidence to support a cerclage wire in these fractures to help control the reduction and is particularly useful with subtrochanteric fractures that have a spiral component.[4]

Successful intramedullary fixation of subtrochanteric fractures is dependent on careful selection of the starting point and knowledge of the specific anatomy of the nail, entering just medial to the tip of the greater trochanter at the junction of the anterior third and posterior two-thirds.[5] Fixation using piriformis entry is possible with the appropriate nails. Careful entry technique preserves reduction position regarding flexion and rotation and prevents varus malreduction.

Surgical experience, careful case selection, familiarity with available implants, instruments, and operating tables, may dictate a lateral decubitus position as surgical access is maximized and reduction facilitated by flexing the affected lower extremity. This position is very advantageous in obese patients where the adipose tissue will fall away from the operative site, thus improving fracture access and facilitating reduction.

DISTAL FRACTURES

Most agree that almost all proximal femur fractures can be managed with nails, but controversy exists when managing distal femur fractures. As surgical techniques and implants change, the limitations of nailing distal fractures are decreasing.

The common forces that limit reduction of distal fractures come primarily from the gastrocnemius muscles. The unopposed pull of the gastrocnemius forces the distal fragment into extension. Successful management of extension, coupled with attention to varus/valgus and rotation are crucial to intramedullary treatment of extreme distal femur fractures. Placing a bump under the knee relaxes the gastrocnemius and provides a counterforce to the muscle pull. Use of a large k-wire as a joystick or placement of an intraoperative femoral fixator or distractor will aid reduction and if carefully positioned, permit reaming and nail placement. In particularly difficult distal fractures, placing a transosseous tensioned wire anteriorly on a traction bow is very helpful. This tensioned wire is placed outside the path of the nail, and manipulation of the bow can also correct varus/valgus angulation. If an intracondylar split is being reduced with a partially threaded cannulated screw, the tension wire may be placed through the screw. Placing the tension wire through the screw and pulling on the traction bow usually results in the best control of the distal fragment.

Specially designed retrograde nails are available with multiple out-of-plane fixation points placed very distally. Some of these nails have been also been engineered that use an end cap to incorporate the distal screw as a fixed-angle device. Thus, by mastering the reduction techniques and using specially designed intramedullary devices, successful reduction and fixation of distal femur fractures can be achieved.

For extra-articular fractures, many would agree that retrograde nailing is preferred to plating. The support of this method has to do with the load-sharing principles of nailing and the chance to have the patient mobilization with early weight bearing. Current studies are examining whether nails are advantageous to plates for treatment of these fractures.

The question then becomes what are the limits of extreme nailing of the distal femur? For some, a nail is used in almost any fracture type, even those involving coronal plane fractures. Adherence to the basic principles of articular fracture care (ie, anatomically reconstructing the joint and connecting the reconstructed joint to the shaft) is the key to avoiding complications with extreme nailing. The joint must be reconstructed without blocking the nail path and this is usually accomplished with multiple independent lag screws. Anatomic alignment of the joint block with the shaft may require multiple blocking screws to create a path for the nail.

ILLUSTRATIVE CASE

A 34-year-old male was ejected from a vehicle and suffered a pneumothorax, diaphragmatic rupture, multiple spinal fractures, a distal humerus fracture, and a closed

AO/OTA 33C3 distal femur fracture. Preoperative X-rays and computed tomography demonstrate an intracondylar split, a coronal plane fracture of the lateral condyle, and extensive shaft comminution (Figs. 2A–D). A just lateral to midline approach was performed on the distal femur using a lateral parapatellar arthrotomy. This approach allows for direct visualization of the coronal plane fracture and the intracondylar split. By using this utility approach, one may still bailout to a plate if intraoperative comminution proves to be greater than expected. The coronal plane fracture was clamped and wires for cannulated screws were placed. Next, the intracondylar split was anatomically reduced utilizing a large periarticular reduction clamp. Two 6.5 mm partially cannulated screws were then placed out of the projected nail path to compress the condyles together. Two partially threaded 4.0-mm cannulated screws were then placed over the guidewires to compress the lateral condyle coronal plane fracture. With the articular block reconstructed, our attention was turned to connecting the joint block to the shaft. A standard entry for a retrograde nail was created and opened with a reamer. A skinny wire was placed through the anterior transcondylar screw and attached to a traction bow. We were then able to pull traction to correct the distal fragment extension, length, and varus/valgus. While holding this position, 4 out-of-plane screws were placed in the long supracondylar nail to secure distal fixation. The nail was then locked proximally with 2 screws to secure length and rotation. Final X-rays demonstrate an anatomic reconstruction (Figs. 2E–G). At 4 weeks, the patient had 0–125 degrees of knee motion, abundant healing, maintenance of the joint reduction, and maintenance of appropriate axial alignment (Figs. 2H–I).

CONTRAINDICATIONS

In the proximal femur, contraindications to nailing included are few. Rare combinations of femoral neck and

FIGURE 2. A, Preoperative anteroposterior showing comminuted intra-articular distal femur fracture. B, Preoperative lateral. C, Cornonal computed tomography cut demonstrating intra-articular split. D, Saggital computed tomography cut demonstrating coronal plane fracture of lateral condyle. E. Intraoperative lateral demonstrating anatomic reconstruction. F, Postoperative anteroposterior. G, Postoperative lateral. H, Four-week postoperative anteroposterior. I, Four-week postoperative lateral.

proximal femur fractures which require open reduction of the neck may be considered a contraindication as the entry of the nail may displace the neck reduction. In the distal femur, extensive comminution of the articular surface is a contraindication to nailing. Also, if the articular block cannot be reconstructed to a stable block using lag screws, nailing would be a poor fixation tactic. Another general contraindication is preexisting deformity of the shaft that would prevent safe nail passage from either antegrade or retrograde insertion.

CONCLUSIONS

Although plates are still an integral part of the fracture surgeon's armamentarium, nailing at the extremes of the femur is becoming more common. This has been made possible by advances in nail technology and surgical expertise. A current multicenter, prospective, randomized study (S.O.L.V.E.D) of nails versus plates for distal fractures is underway and should help delineate which fracture nailing optimally treats. Uneventful healing with anatomic alignment, rotation, and length can be achieved with nails at both far proximal and far distal fractures of the femur so long as the basic principles of fracture care (ie, acceptable reduction) are not abandoned.

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