# Intramedullary Nailing of Proximal Femur Fractures

Kenneth J. Koval, MD

## Abstract

**Despite the general success of the sliding hip screw for stabilization of intertrochanteric fractures, there is dissatisfaction with the resultant deformity associated with its use, particularly in unstable fracture patterns. These concerns have resulted in increasing use of intramedullary devices for treatment of peritrochanteric fractures. Use of an intramedullary device for peritrochanteric fracture stabilization limits the amount of lag screw sliding and resultant limb deformity, particularly shortening, since the fracture can settle only until the proximal fragment abuts against the nail. This article describes some of the advances in intramedullary nails used to stabilize peritrochanteric fractures.**

The incidence of hip fractures in the United States is approximately 80 per 100,000.[1] It is estimated that 250,000 hip fractures occur each year in this country in patients over the age of 65 years; some have predicted that this number will double or triple by the year 2050,[2] others, that this doubling or tripling will occur within the next 20 years.[3-5]

Approximately, 50% of hip fractures involve the peritrochanteric region. Factors associated with peritrochanteric fractures include advancing age, increased comorbidities, increased dependency in activities of daily living, and a history of other osteoporosis-related (fragility) fractures.[6]

Ninety percent of peritrochanteric fractures in the elderly result from a simple low-energy fall. Peritrochanteric fractures in younger individuals are usually the result of a high-energy injury such as a motor vehicle accident or fall from a height.

## Radiographic Evaluation

Standard radiographic examination of the hip includes an anteroposterior (AP) view of the pelvis and an AP and cross-table lateral view of the involved proximal femur. The AP pelvis view allows comparison of the involved side with the contralateral side and can help to identify nondisplaced fractures. The lateral radiograph aids in the assessment of proximal femur posterior comminution. An internal rotation view of the injured hip may further clarify the fracture pattern. Internally rotating the involved femur 10° to 15° offsets the anteversion of the femoral neck and provides a true AP view of the proximal femur. An AP view of the contralateral side can be used for preoperative planning.

Dr. Koval is professor, Dartmouth-Hitchcock Medical Center, Lebanon, NH.

## Classification

Because some studies have documented poor reproducibility of the various peritrochanteric fracture classification systems,[7] many authors prefer to classify these fractures as either stable or unstable, depending on the status of the posteromedial cortex. In stable fracture patterns, the posteromedial cortex remains intact or has minimal comminution, making it possible to obtain a stable reduction. Unstable patterns are characterized by greater comminution of the posteromedial cortex at the level of the lesser trochanter. Unstable fracture patterns comprise those with posteromedial comminution, subtrochanteric extension, or a reverse obliquity pattern.

## Treatment

Operative management is the treatment of choice for virtually all peritrochanteric fractures. Consisting of fracture reduction and stabilization, it permits early patient mobilization and minimizes many of the complications of prolonged bed rest such as atelectasis, decubiti, urinary tract infection, and mental status changes. The main indication for nonoperative management is a patient who is too ill for operative treatment.

## Implant Choice

Historically, the sliding hip screw has been the implant of choice for stabilization of both stable and unstable peritrochantericfractures.[8] Despite its general success, there is dissatisfaction with the resultant deformity associated with its use to stabilize unstable fracture patterns. Excessive sliding of the lag screw within the plate barrel results in limb shortening and medialization of the distal fragment (Figure 1). Jacobs and colleagues reported that the average fracture settling in stable patterns was 5.3 mm and in unstable patterns was 15.7 mm.[9] Another study reported that excessive sliding was the major factor causing fixation failure in unstable fracture patterns.[10] Medialization of the femoral shaft greater than one third of its diameter is associated with a 7-times increased rate of fixation failure.[11] Baixauli and colleagues reported that sliding greater than 15 mm was associated with increased incidence of postoperative pain.[12]Another study reported similar findings with sliding greater than 20 mm.[13]

Dissatisfaction with use of a sliding hip screw in unstable fracture patterns led to the development of intramedullary nails designed specifically for stabilization of peritrochanteric fractures. These nails offer several potential advantages: 1) An intramedullary nail, because of its central location, theoretically provides more efficient load transfer than a sliding hip screw. 2) The shorter lever arm

**Figure 1.** Anteroposterior of the proximal femur demonstrating limb deformity with limb shortening and medialization of the distal fragment after stabilization of an unstable intertrochanteric fracture with a sliding hip screw.

**Figure 2.** Penetration of anterior femoral cortex because of mismatch of nail curvature.

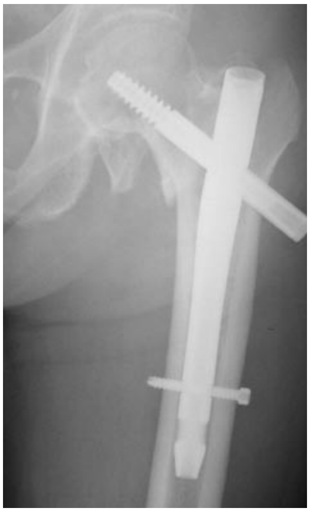

**Figure 3.** Lag screw prominence in the lateral thigh.

of the intramedullary nail can be expected to decrease tensile strain on the implant, thereby decreasing the risk of implant failure. 3) Because the intramedullary nail incorporates a sliding hip screw, the advantage of controlled fracture impaction is maintained. 4) The intramedullary location limits the amount of sliding and, therefore, limb shortening and deformity that can occur compared with the sliding hip screw—the fracture can settle only until the proximal fragment abuts against the nail. 5) Insertion of an intramedullary nail theoretically requires shorter operative time and less soft tissue dissection than a sliding hip screw, potentially resulting in decreased overall morbidity. (6) Use of a long intramedullary nail protects against subsequent fracture in the same femur.

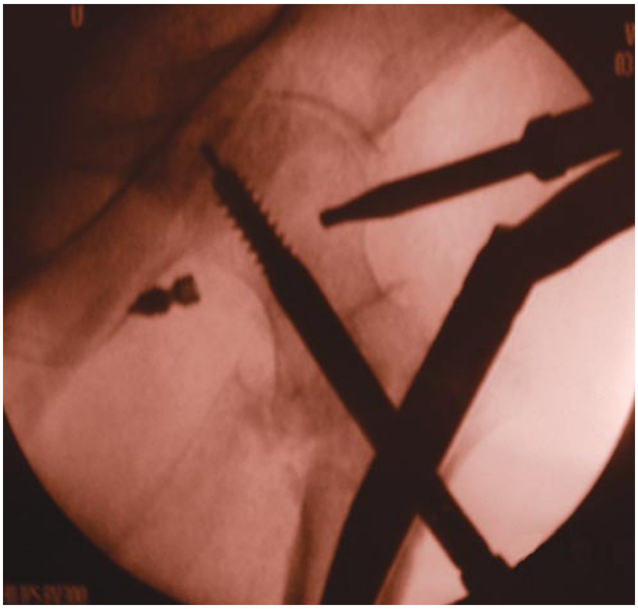

**Figure 4.** Loss of the set screw into the soft tissue.

**Figure 5.** Anteroposterior radiograph demonstrating the "Z effect".

Many types of intramedullary devices can be used for stabilization of proximal femur fractures. All have similar basic characteristics: 1) They are designed for insertion through the greater trochanter, requiring a valgus offset of proximal nail. 2) The proximal aspect of nail must be sufficiently wide to allow large diameter lag screw passage. 3) They can be placed through a small incision. 4) They can be statically locked. 5) They limit the amount of screw sliding and subsequent proximal deformity of the proximal femur. 6) They are more expensive than a sliding hip screw.

## Comparing Intramedullary Nails with Sliding Hip Screws

Results of most studies that have compared intramedullary hip screws and sliding hip screws for stable peritrochanteric fractures have revealed no significant differences with respect to operating time, duration of hospital stay, infection rate, wound complications, implant failure, lag screw cut-out, or screw sliding. However, patients treated with early designs of the intramedullary hip screw were at increased risk for femoral shaft fracture at the nail tip and the insertion sites of the distal locking screws.

A prospective, randomized study comparing use of a sliding hip screw with use an intramedullary hip screw for stabilization of 100 intertrochanteric fractures in patients older than 60 years[14] showed operative time to be significantly greater for the intramedullary device; however, estimated intraoperative blood loss was significantly lower. There were 1 intraoperative femur fracture and 2 greater trochanteric fractures associated with use of the intramedullary hip screw, but no late postoperative fractures. The in-hospital and 6-month mortality rates were similar for the 2 treatment groups. Patients whose fractures were stabilized using the intramedullary hip screw experienced significantly better mobility at 1 and 3 months' follow-up. This difference was no longer found at 6 and 12 months, although patients who received the intramedullary device enjoyed significantly better walking ability outside the home at all times. An important finding was that the intramedullary hip screw was associated with significantly less screw sliding and limb shortening, particularly when used to stabilize unstable fracture patterns.

Adams and colleagues reported a prospective randomized study comparing a sliding hip screw with an intramedullary nail for treatment of intertrochanteric fractures.[15] Two hundred and three patients were stabilized with a short Gamma nail while 197 received a sliding hip screw. Patients were followed for 1 year. Use of the Gamma nail was associated with a higher risk of postoperative complications, including perioperative fracture; however, this Gamma nail was an early design with a large diameter of the distal nail and locking bolts. Harrington performed a similar prospective randomized trial comparing use of the intramedullary hip screw with use of a sliding hip screw for the treatment of unstable intertrochanteric fractures.[16]

A structured literature review by the Cochrane library concluded that given the lower complication rates and similar functional outcomes, a sliding hip screw is superior for intertrochanteric fracture fixation.[17] However, studies are needed to determine whether intramedullary nails might be superior for select fracture types (reverse obliquity fractures) or certain patient characteristics (younger, more active individuals).

## Problems With Existing Nails

Several problems exist with use of the currently available intramedullary nails, including the following: 1) penetration of the anterior femoral cortex because of mismatch of nail curvature and intact femur; 2) lag screw prominence in the lateral thigh during fracture settling; 3) creation of a large hole in greater trochanter with sacrifice of part of the abductors; 4) freehand insertion of the set screw necessary to capture the lag screw; and 5) potential for the Z-effect.

With full-length nails, impingement of the distal aspect of the nail on the anterior femoral cortex can occur, secondary to a mismatch of the nail curvature and femoral bow (Figure 2). This anterior cortical impingement can result in cortical perforation if the nail is impacted down the femoral canal with use of a mallet. Egol and colleagues examined the curvature of 892 femurs and compared them with the curvatures of 8 antegrade intramedullary femoral nails.[18] They reported that the average femoral anterior radius of curvature was 120 cm (± 36 cm). Radii of curvature of the intramedullary nails ranged from 186 to 300 cm (straighter than the femurs). Newer nail designs have partially corrected the mismatch to reduce the incidence of nail penetration through the anterior cortex.

Lag screw prominence in the lateral thigh results from sliding of the lag screw through the nail as the fracture impacts to a stable position (Figure 3). This lag screw prominence results in soft tissue impingement and lateral thigh pain when the patient attempts to lie on the affected side. A newer nail design (peritrochanteric nail [PTN] Biomet Trauma, Parsippany, NJ) has addressed this problem with a lag screw that telescopes within a fixed barrel.

The large proximal nail diameter necessary to incorporate a sliding lag screw requires creation of a large hole in the greater trochanter. This entry diameter has led to concerns about disruption of the abductor insertion. In one cadaver study, the 17-mm reamer for the Gamma nail was shown to remove on average 27% of the gluteus medius insertion.[18]

Some of the intramedullary nails require freehand insertion of the set screw used to capture the lag screw within the nail. In obese patients, insertion of this set screw “free hand” can be problematic and has resulted in loss of the set screw into the soft tissue (Figure 4). Some newer nail designs have incorporated placement of the set screw into the nail, eliminating the need for later insertion. Periprosthetic fractures were more common with the first-generation short trochanteric Gamma nails, likely as a result of the large distal diameter, larger proximal bend, and large–diameter distal screws.

The Z-effect phenomenon, originally reported by Werner-Tutshcku and colleagues,[19] describes a complication of double lag screw intramedullary nail designs, in which the 2 proximal lag screws appear to migrate in opposite directions during physiologic loading (Figure 5).[20] The exact etiology of the Z-effect has yet to be determined but does not seem to occur with nail designs that incorporate a lag screw that slides within a barrel.

### My Opinion

I currently use a sliding hip screw with a 2-hole side plate for stable intertrochanteric hip fractures and an intramedullary hip screw for unstable fracture patterns. With stable fracture patterns, minimal fracture settling should occur, resulting in minor limb shortening and medialization of the distal fragment. In unstable fracture patterns, I prefer use of an intramedullary type device. I usually select a full-length nail to minimize the risk of periprosthetic fracture secondary to a stress riser effect at the tip of the nail and locking bolt insertion sites and to protect the entire femur against possible

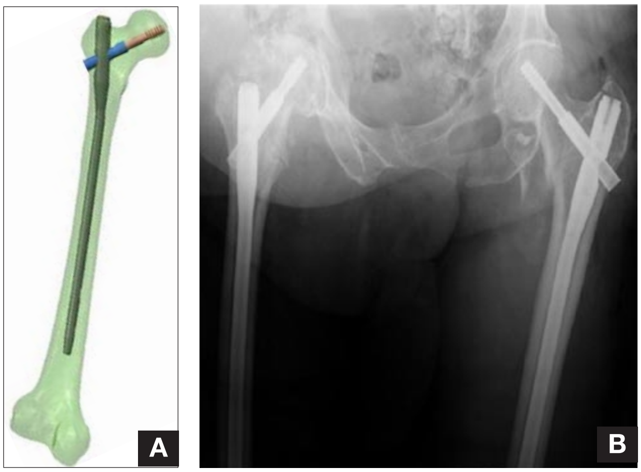

Figure 6. Drawing (A) and radiograph (B) of the Peritrochanteric Nail (Biomet Trauma, Parsippany, NJ)

later fractures in the vulnerable elderly population, secondary to subsequent falls.

The nail I prefer for treatment of peritrochanteric fractures is the PTN (Figure 6). Made of titanium alloy, it has better match of the nail curvature to the femoral bow with a nail curvature of 180 cm. It has a small proximal diameter (15.9 mm) that results in creation of a smaller hole in the greater trochanter for nail insertion. Its distal diameter of 11 mm results in a more flexible nail that reduces the risk of iatrogenic fracture comminution during insertion. It has a lag screw that telescopes within a fixed barrel attached to the nail and cannot protrude laterally beyond the lateral aspect of the barrel; this prevents soft tissue impingement of the lag screw laterally as the fracture settles and may prevent the Z-effect. The PTN also has a fixed-lag screw option that will not slide within the nail and is indicated for subtrochanteric fractures. Incorporation of the set screw into the nail during the manufacturing stage eliminates the need for later insertion.

Like unstable intertrochanteric fractures, intertrochanteric fractures with subtrochanteric extension are best treated with an intramedullary nail.

## Reverse Obliquity Fractures

Reverse obliquity fractures are best stabilized with an intramedullary nail. The intramedullary location provides a buttress against lateral displacement and decreases the bending strain on the implant. For surgeons who prefer open plating techniques, a 95° fixed-angle plate (does not allow sliding) is indicated for these fractures; compared with a 135° sliding hip screw, this device provides more cortical purchase on the proximal fragment and eliminates the potential for rotational instability.[21] A sliding hip screw is not indicated for stabilization of reverse obliquity fracture patterns.

Sadowski and colleagues reported a prospective randomized series of reverse obliquity fractures stabilized using either an intramedullary nail (20 patients) or a 95º fixed-angle plate (19 patients).[22] Patients treated with the intramedullary nail had shorter operative times, fewer blood transfusions, and shorter hospital stays.

## Summary

There has been growing use of intramedullary nails for treatment of proximal femur fractures, particularly in unstable patterns at high risk for shortening. Recent advances in nail design have decreased the complication rates reported with use of the initial design intramedullary nails. More randomized clinical trials are needed to determine the optimum device for stabilization of these difficult fractures.

## Author's Disclosure Statement

Dr. Koval reports that he has received financial or material support from Biomet, Inc, and is a consultant to Biomet, Inc.

## References

1. Gallagher JC, Melton LJ, Riggs BL, Bergtrath E. Epidemiology of fractures of the proximal femur in Rochester, Minnesota. *Clin Orthop Relat Res*. 1980;(150):163-171.
2. Cummings SR, Rubin SM, Black D. The future of hip fractures in the United States. Numbers, costs, and potential effects of postmenopausal estrogen. *Clini Orthop Relat Res*. 1990(252):163-166.
3. Zain Elabdien B, Olerud S, Karlstrom G, Smedby B. Rising incidence of hip fracture in Uppsala, 1965-1980. *Acta Orthop Scand.* 1984;55(3):284-289.
4. Gerhart T. Managing and preventing hip fractures in the elderly. J of *Musculoskeletal Med*. 1987;4:60-68.
5. Luthje P. Incidence of hip fracture in Finland. A forecast for 1990. *Acta Orthop Scand*. 1985;56(3):223-225.
6. Koval KJ, Aharonoff GB, Rokito AS, Lyon T, Zuckerman JD. Patients with femoral neck and intertrochanteric fractures. Are they the same? *Clin Orthop Relat Res.* 1996;(330):166-172.
7. Gehrchen PM, Nielsen JO, Olesen B. Poor reproducibility of Evan's classification of the trochanteric fracture. *Acta Orthop Scand.* 1993;64(1):71-72.
8. Cantu RV, Koval, KJ: Intertrochaneric fractures. In: Bucholz RW, Heckman JD, Court-Brown CM, et al,eds. *Rockwood and Green's Fractures in Adults*. 6th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2006:1793-1825.
9. Jacobs RR, McClain O, Armstrong HJ. Internal fixation of intertrochanteric hip fractures: A clinical and biomechanical study. *Clin Orthop Relat Res.* 1980;(146):62-70.
10. Rha JD, Kim YH, Yoon SI, Park TS, Lee MH. Factors affecting sliding of the lag screw in intertrochanteric fractures. *Int Orthop.* 1993;17(5):320-324.
11. Parker MJ, Pryor GA. Gamma versus DHS nailing for extracapsular femoral fractures: Meta-analysis of ten randomised trials. *Int Orthop*. 1996;20(3):163-168.
12. Baixauli F, Vincent V, Baixauli E, et al. A reinforced rigid fixation device for unstable intertrochanteric fractures. *Clin Orthop Relat Res*. 1999;(361):205-215.
13. Kim WY, Han CH, Park JI, Kim JY. Failure of intertrochanteric fracture fixation with a dynamic hip screw in relation to pre-operative fracture stability and osteoporosis. *Int Orthop*. 2001;25(6):360-322.
14. Hardy D, Descamps P, Krallis P, et al. Use of an intramedullary hip-screw compared with a compression hip-screw with a plate for intertrochanteric femoral fractures. A prospective, randomized study of one hundred patients. *J Bone Joint Surg Am.* 1998;80(5):618-630.
15. Adams CI, Robinson CM, Court-Brown CM, et al. Prospective randomized controlled trial of an intramedullary nail versus dynamic screw and plate for intertrochanteric fractures of the femur. *J Orthop Trauma*. 2001;15(6):394-400.
16. Harrington P, Nihau A, Ingrain AK, et al. Intramedullary hip screw versus sliding hip screw for unstable intertrochanteric femoral fractures in the elderly. *Injury*. 2002;33(1):23-28.
17. Parker MJ, Han doll HH. Gamma and other cephalocondylic intramedullary nails versus extramedullary implants for extracapsular hip fractures in adults. (Cochrane Review). *Cochrane Database Syst Rev.* 2005; Oct 19(4): CD000093.
18. Egol KA, Chang EY, Cvitkovic J, Kummer FJ, Koval KJ. Mismatch of current intramedullary nails with the anterior bow of the femur. *J Orthop Trauma.* 2004;18(7):410-415.
19. Werner-Tutschku W, Lajtai G, Schmiedhuber G, Lang T, Pirkl C, Orthner E. Intra- and perioperative complications in the stabilization of per- and subtrochanteric femoral fractures by means of PFN. *Unfallchirurg.* 2002;105(10): 881-885.
20. McConnell T, Tornetta P III, Benson E, Manuel J. Gluteus medius tendon injury during reaming for gamma nail insertion. *Clin Orthop Relat Res.* 2003;407:199-202.
21. Haidukewych GJ, Israel TA, Berry DJ. Reverse obliquity fractures of the intertrochanteric region of the femur. *J Bone Joint Surg Am*. 2001;83A(5):643-650.
22. Sadowski C, Lubbeke A, Saudan M, Riand N, Stern R, Hoffmeyer P. Treatment of reverse oblique and transverse intertrochanteric fractures with use of an intramedullary nail or a 95 degree screw-plate: a prospective, randomized study. *J Bone Joint Surg Am*. 2002; 84A(3):372-381.