# Retrograde Nailing for Treating Femoral Shaft Fractures: A Review

**Thomas A. DeCoster, MD; Brianna N. Patti, MD**

Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center, Albuquerque, New Mexico

***Corresponding Author*** Thomas A. DeCoster. Department of Orthopaedics & Rehabilitation, MSC 10 5600, 1 University of New Mexico, Albuquerque, NM 87131 (email: tadabq@aol.com).

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## ABSTRACT

Rigid intramedullary nailing is an effective procedure for treating fractures of the femoral shaft. Although antegrade nailing is the traditionally used technique, retrograde nailing offers various advantages. A companion article published in the seventh volume of *The University of New Mexico Orthopaedics Research Journal* addressed antegrade femoral nailing. This review will describe retrograde nailing of femoral shaft fractures, including a brief history, indications, detailed technique, outcomes, advice (or "pearls"), and common failures (or "pitfalls"). Retrograde nailing for treating femoral shaft fractures can provide successful results similar to those of antegrade nailing in general and advantages in particular situations such as more distal shaft, bilateral, and certain associated fractures.

***Keywords:*** Intramedullary Nailing, Retrograde Nailing, Femur Shaft Fracture

## INTRODUCTION

Reamed, locked, rigid intramedullary (IM) nailing is an effective treatment of most fractures of the femoral shaft. Antegrade nailing has been the traditionally standard technique,[1-4] but use of retrograde nailing offers various advantages.[5-7] Antegrade nailing was described in detail in the companion article published in the same journal.[8] An alternative technique is retrograde nailing, in which the intercondylar notch of the distal femur is used as the entry point.

Retrograde medullary nailing for treating fractures of the femoral shaft using a distal, extraarticular entry portal through the medial femoral supracondylar region was initially proposed. This required a bend in the nail and created a large stress riser. Results were improved with the development of an intraarticular intercondylar entry site in line with the medullary canal and using standard nail designs. This technique was originally advocated for the treatment of patients with ipsilateral fractures of the femoral neck and shaft.[9] Its indications were expanded to include patients with multiple injuries to facilitate the performance of simultaneous or sequential procedures.[10]

Advantages of retrograde nailing include avoiding use of a fracture table and traction, easier patient positioning and nail insertion, and shorter operating times with less blood loss.[11] The entry site is easier to access because of less soft-tissue dissection, especially in large patients. Furthermore, there is no muscle dissection and less exposure to radiation, especially to pelvic organs. Femoral shaft fractures of both thighs can be treated with the same positioning. In general, retrograde nailing may be preferable to antegrade nailing in the following situations: 1) the presence of a concomitant (possibly non-displaced) femoral neck fracture; 2) the presence of previously or simultaneously placed internal fixation of a proximal femoral fracture; and 3) the possibility of causing a femoral neck fracture by placement of an antegrade nail.

The retrograde technique can be used when proximal access to the medullary canal is blocked. Although early results with retrograde nails suggested a slightly lower union rate, the difference may have resulted from other factors such as smaller diameter nails and use of unreamed nails.[6,12-15] Use of this technique, with retrograde nails matched to the diameter of the femoral isthmus using reaming, has shown promising outcomes. Findings include healing rates and results equivalent to those of the antegrade technique, with high rates of rapid union and low complications.[6,12-15] Entry-site problems may be equivalent between retrograde (knee symptoms) and antegrade (hip symptoms) techniques.

The current article describes indications, contraindications, and current techniques associated with retrograde nailing for treating femoral shaft fractures. We will examine differences between antegrade and retrograde approaches with IM nailing. We will also review surgical techniques used in retrograde nailing, including positioning, incision, entry site, fracture reduction, reaming, nail insertion, locking screws, rod caps, wound closure, postoperative management, treatment outcomes, benefits, and complications. We will provide "pearls" (ie, advice) and "pitfalls" (ie, common failures) to assist orthopaedic surgeons with effectively implementing this method.

***Table 1.*** Relative indications of performing retrograde (vs antegrade) nailing for treating femoral shaft fractures

| *Indication* | *Details or reasoning* |
|---|---|
| Multisystem injury | Chest, abdomen, head |
| Femoral shaft fractures | Fractures distal to the isthmus, gunshot wound |
| Hip soft-tissue injury | -- |
| Trauma involving multiple extremity fractures | -- |
| Ipsilateral femoral neck and femoral shaft | Retrograde nail and hip plate |
| Ipsilateral acetabular and femoral shaft | Preserve surgical approach to the acetabulum |
| Ipsilateral pelvic ring disruption and femoral shaft | Avoid perineal post, traction, and pelvic displacement |
| Ipsilateral femoral supracondylar and femoral shaft | Better distal fragment fixation |
| Ipsilateral tibial and femoral shaft[a] | Single incision for nailing both |
| Bilateral femoral shaft | Obviates need for repositioning and preparation |
| Proximal to TKA with femoral component[b] | Improved distal fixation in distal patterns |
| Morbid obesity | Ease of entry point access |
| Pregnancy | Less radiation to pelvis |
| Surgeon preference | Ease of positioning, entry point access, reduction, nail placement, less operating times and blood loss |

TKA, total knee arthroplasty; --, not applicable.
[a]Right femoral shaft fracture and left femoral shaft fracture.
[b]Open-box design of the femoral component.

***Table 2.*** Relative and absolute contraindications of performing retrograde (vs antegrade) nailing for treating femoral shaft fractures

| *Relative contraindication* | *Absolute contraindication* |
|---|---|
| Fractures located within 5 cm of the lesser trochantera | Retained implant blocking retrograde medullary access |
| < 45° of knee flexion[b] | Open distal femoral physis |
| Prior knee infection[c] | |
| Significant soft tissue-injury about the knee[d] | |
| Patella baja[e] | |
| Entry point may require ablation of some portion of the inferior extra-articular patella[f] | |

[a]Poor proximal fragment stability.
[b]Difficult access to entry point.
[c]Risk of spreading to femur.
[d]Proximal incision may be better tolerated.
[e]Can also use medial arthrotomy approach.
[f]If using transpatellar tendon approach.

## INDICATIONS AND CONTRAINDICATIONS

Table 1 shows relative indications of retrograde (versus antegrade) nailing.[2,9,16-23] In general, retrograde is preferred to antegrade in the presence of an associated condition particularly problematic for antegrade insertion.[12,21-24] Retrograde nailing is generally contraindicated in the scenarios depicted in Table 2.[11,25,26]

## SURGICAL TECHNIQUE

### *Positioning and Incision*

Place the patient on a radiolucent table in the supine position.[19] The extremity can be stabilized by a tibial traction pin, although this is not required. Manual traction or use of a femoral distractor can aid in fracture reduction, but most cases require no special equipment for traction reduction. The fluoroscope is positioned contralateral to the injured side to provide access to the medial and lateral sides of the distal femur. A 4-cm longitudinal incision is made in line with the center of the patellar tendon. The tendon can be split in line with its fibers or dissection can be performed medial to the patellar tendon.

### *Entry Site*

The fracture should be reasonably reduced to avoid a malreduction by a malplaced entry channel. This is critically important with retrograde nailing in contrast to antegrade nailing. The entry point is located at the top of the intercondylar notch, about 1 cm anterior to the insertion of the posterior cruciate ligament (Figure 1). A guide pin is placed in this location, which is in the center of the distal femur on both the anteroposterior (AP) and lateral views of fluoroscopic projections.

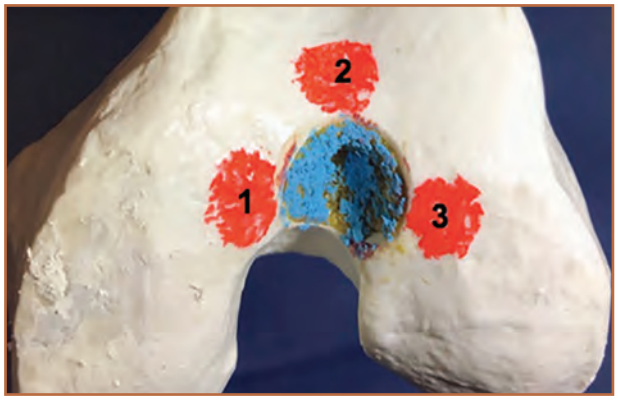


***Figure 1.*** Distal femur sawbone, showing correct and incorrect entry points. Blue indicates correct center-center entry point for a retrograde femoral nail, whereas red indicates common errors in entry-site placement. Other marked errors include: 1) too medial, resulting in lateral translation or apex lateral deformity; 2) too anterior, resulting in postertior translation or apex posterior deformity; and 3) too lateral, resulting in medial translation or apex medial deformity.

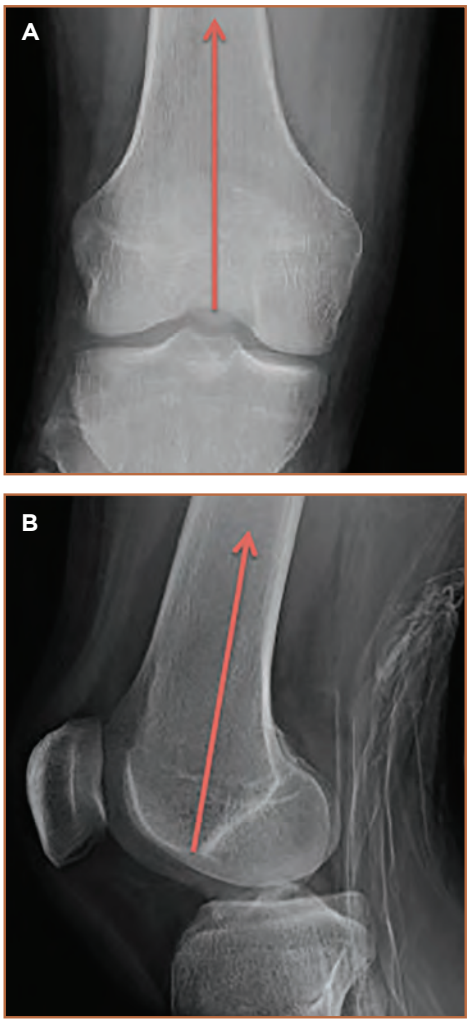


***Figure 2.*** A) Anteroposterior and B) lateral radiographs femoral shaft fractures treated with retrograde nailing, showing recommended entry point and trajectory of guide pin (red arrow).

A guide pin is drilled 6 cm into the distal femur parallel to the medullary canal. The position of the guide pin is confirmed with biplanar fluoroscopic views, in the center on both AP and lateral projections with the fracture aligned (Figures 2A and 2B). The entry reamer is placed over the guide pin into the distal fragment. A sleeve with suction helps minimize osteochondral debris in the knee joint and minimizes trauma to the skin and patellar tendon.

***Fracture Reduction and Ball-Tipped Guide Passage***

The ball-tipped guide rod is inserted into the reduction tool, and both are inserted into the distal fragment of the femur. External manipulation of the thigh aligns the relatively mobile distal fragment to the relative stable proximal fragment. The guide wire is advanced across the reduced fracture into the proximal fragment. The reduction tool is removed. The ball-tipped guide is advanced to the level of the proximal edge of the lesser trochanter. The measuring sleeve is slid down until it aligns with the entry site, and nail length is measured. Care should be taken to ensure that the fracture reduction is at proper length (ie, not distracted or shortened).

After nail length measurement, the ball-tipped guide is advanced into the proximal femur so that it is not removed during reaming. Passage of the ball-tipped guide is typically easy and takes a few seconds, unlike antegrade nailing. Rotation of the limb is adjusted by comparing it with the uninjured leg, imaging the profile of the lesser trochanter in the injured leg, and matching the rotation of the distal fragment to that of the proximal fragment.

***Reaming***

Serial reaming of the femoral canal is started with an end-cutting reamer advanced to the level of the lesser trochanter, again using a sleeve and obturator. Fracture reduction should be maintained during reaming. Reaming can progress in 1-mm increments until cortical chatter, which is typically encountered at about 11 mm. It is recommended to use a rod diameter of 1 mm less than the largest reamer passed.[27]

***Nail Insertion***

The appropriately sized nail is selected and mounted onto the rod-driver assembly. The locking-screw guides are checked, and the orientation and diameter of the locking screw holes are confirmed. The nail-driver assembly is placed over the guide wire and into the femoral entry site. The nail is driven to the desired position using gentle blows while monitoring the guide wire to ensure that it does not advance with the rod. Fracture reduction is maintained during nail insertion. The nail must be seated 5 mm below the articular surface.[16] If a rod cap is planned, the rod should be seated 15 mm beneath the articular surface as confirmed on lateral views of fluoroscopic images. The tip of the nail proximally should be at the level of the lesser trochanter.

### *Locking*

The distal interlocking screws are placed with the aid of the nail-mounted guide. It should be confirmed that the nail is recessed immediately before placing the distal locking screw.[17] An incision is made laterally where the drill sleeves meet the skin, and a longitudinal split is made in the fascia lata. The drill sleeve is seated down to bone. The specific drill bit is used to drill through to the endosteum of the far cortex and length measured. A maximum of 5 mm is added, and the far cortex is drilled. A depth gauge can be used to confirm the length of the screw. The screw is inserted through the nail with bicortical purchase. The procedure is repeated for the second screw. Oblique screws and medial-to-lateral screws using the nail-mounted guide may be used when more distal fixation is desired such as in relatively distal fractures.

The proximal AP screws can be placed freehand with fluoroscopy.[28] Correct length and rotation of the fracture should be confirmed immediately before proximal locking. A perfect circle of the hole in the proximal nail in the subtrochanteric zone is obtained using AP fluoroscopy, and the skin over the hole is marked. A 2-cm longitudinal incision is made, and the quadriceps are bluntly dissected longitudinally to periosteum with a Freer elevator (Sklar Surgical Instruments, West Chester, PA). The tip of the drill bit is centered over the hole and the drill is aligned parallel to the X-ray beam and perpendicular to the shaft of the femur. Both cortices are drilled through the hole in the nail, and the screw is placed. A 30-mm length screw is almost always used.

There is a low potential risk of injury to the femoral nerve (which has branched at this level) and the superficial femoral artery (which is far medial). The sciatic nerve could be injured with excessive penetration beyond the posterior cortex. Static and dynamic proximal interlocking options have been described.[20] Alternative techniques have been developed that are particularly helpful to the surgeon who does few nails.[29]

### *Rod Cap, Set Screw, and Wound Closure*

Some systems have rod caps that seal the cannulation in the nail. This cap may theoretically help prevent synovial fluid from tracking into the medullary canal or medullary contents from migrating into the knee joint. Some designs purposely impinge on the distal-most interlocking screw, providing a more rigid, fixed angle device and avoiding toggle.

When rod caps are used, the effective nail length is increased; subsequently, surgeons should be certain whether the nail has been recessed sufficiently to prevent protrusion into the joint or contact with the patella in knee flexion. The tip of the screw cap must be 5 mm below the level of the articular surface. The use of a nail cap and the instrumentation necessary for its subsequent removal should be conspicuously noted in the operating dictation. The wounds and knee joint are copiously irrigated and closed in layers. Suture fixation of the split patellar tendon is usually not necessary but the senior author (TAD) routinely closes the peritendinous layer of Marshal.

## POSTOPERATIVE MANAGEMENT

At the completion of the procedure, the limb is assessed for length and rotation. A ligamentous examination of the knee is performed and documented. The femoral neck should be radiographically inspected for signs of fracture with biplanar fluoroscopy. Plain radiographs are obtained of the entire femur in two planes and reviewed to assess fracture reduction, implant position, and the absence of intraoperative complications (Figures 3A and 3B; Figures 4A through 4D).

Postoperative management of femoral shaft fractures depends on the extent and severity of other injuries. Most isolated closed fractures can immediately begin treatment with weight bearing as tolerated by the patient. Crutches or a walker are used for the first 6 weeks postoperatively. Restricted weight bearing is recommended in cases of poor adherence to medical advice, extensive comminution of the fracture, or notable lower-extremity articular injuries. Limited but appropriate amounts of postoperative analgesia should be prescribed. Hip and knee range of motion and strengthening exercises are started after 2 days.

Routine follow-up consists of a 2-week clinic visit for removal of skin sutures. Subsequent follow-up should occur every 6 weeks, with a newly obtained radiograph every visit until union is observed. This typically continues for 4 to 6 months, until the patient regains full function. A final clinic visit is at 1-year after the injury (Figures 5A and 5B). Nail removal is rarely indicated. Delayed unions can be effectively managed with dynamization by removal of the proximal locking screws.[30]

## POSTOPERATIVE OUTCOMES

Retrograde nailing helps restore both form and function and produces remarkably good short and long-term results with low complication rates.[11] Initial results of retrograde technique using smaller-diameter nails showed promising results but higher non-union rates than that of antegrade nailing.[31,32] When equivalent diameter (ie, 10 mm) nails were used, the reported non-union rate is the same as that of antegrade nails (< 5%).[13,14,33] Initial results have also indicated an increased rate of knee problems including knee stiffness, patella baja, heterotopic ossification, and metallosis and medullary debris in the knee joint.[28]

However, subsequent results have shown that knee stiffness is temporary and that knee motion at 3 months is the same between antegrade and retrograde nailing.[13] Furthermore, the overall incidence of knee problems after retrograde nailing is similar to that of hip problems



***Figure 3.*** A) Anteroposterior and B) lateral radiographs of an acute open femoral shaft fracture.

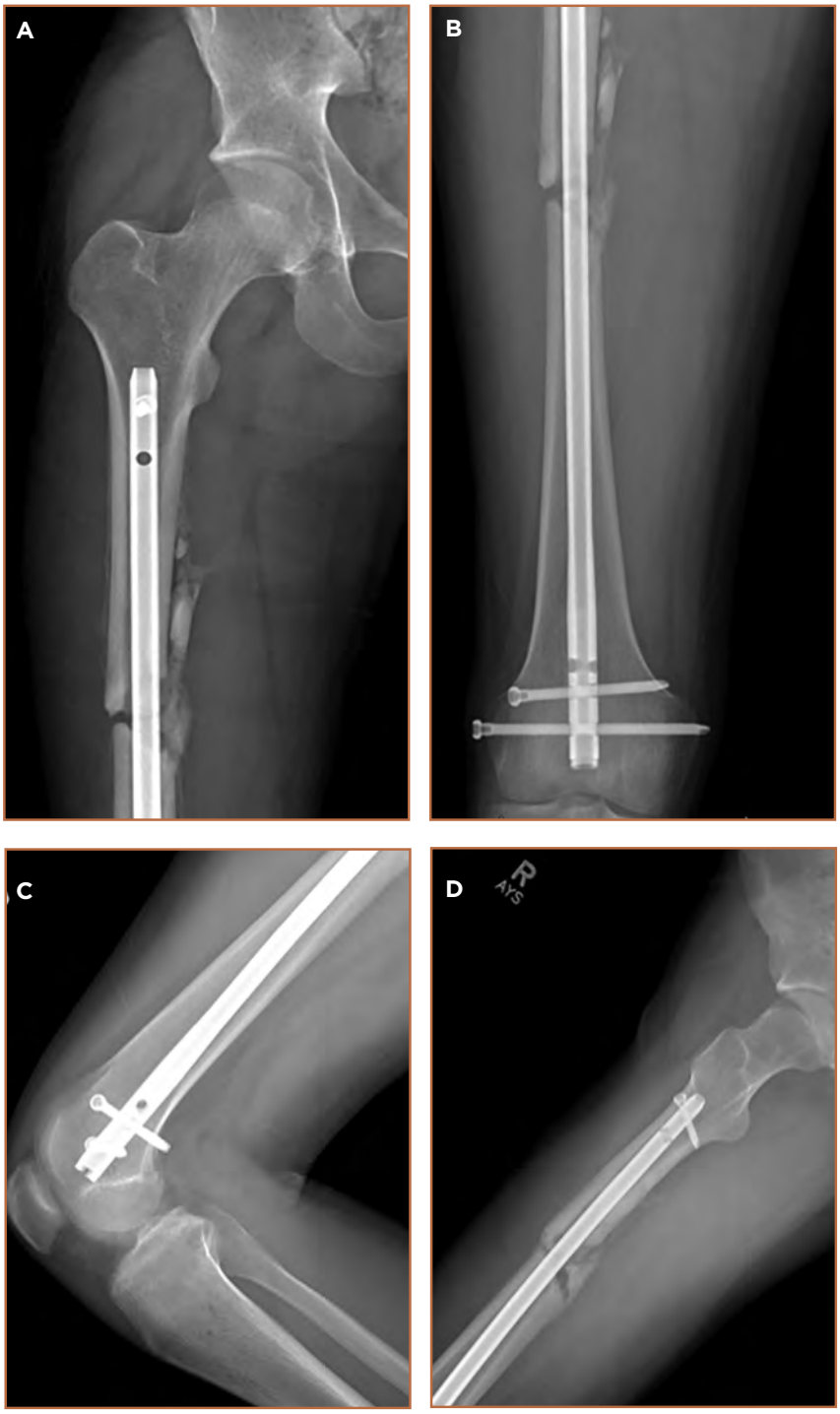


***Figure 4.*** Radiographs of patient shown in Figure 3 after reduction of femoral shaft fracture and fixation with retrograde intramedullary nail. Anteroposterior view A) proximal and B) distal. Lateral view C) distal and D) proximal.



***Figure 5***. Radiographs of patient shown in Figure 3, showing healed femoral shaft fracture after fixation with a retrograde intramedullary nail. A) Anteroposterior and B) lateral views.

after antegrade nailing. Therefore, "entry-site problems" are equivalent between retrograde and antegrade nailing. Findings of studies have clearly shown that retrograde nailing involves easier positioning, requires less equipment, has shorter operating time, less blood loss, and less radiation than those of antegrade nailing.[4,6,23] There are specific indications in which these advantages may result in theoretical benefits to patients (Table 1). There is no indication that retrograde nailing causes more permanent loss of function and soft-tissue problems to the knee joint than antegrade nailing causes at the hip.[16]

## PEARLS AND PITFALLS

When performing IM nailing using a retrograde approach, surgeons should consider the following pearls to help achieve a satisfactory radiological and functional result (Table 3). As with many surgical procedures, physicians should follow a methodical approach to pre-, intra-, and postoperative care of patients treated

***Table 3.*** Advice, or "pearls," to consider when performing retrograde nailing to treat femoral shaft fractures

| *No.* | *Advice* | *Details* |
|---|---|---|
| 1 | Reasonably align the fracture before entry reaming for all retrograde nails | Angular deformity will induce the same deformity after nail insertion |
| 2 | Correct angle of proximal locking screw entry site if not straight anterior | Otherwise, the nail or fracture is likely mal-rotated |
| 3 | Check for an occult femoral neck fracture after proximal interlocking | Use live fluoroscopy |
| 4 | Identify knee ligament injuries after proximal and distal interlocking | Identify by performing a full knee examination |
| 5 | Use a captured screw driver or absorbable suture looped around the screw head to avoid losing the screw in thigh soft tissue | Especially when proximally locking; the screw is difficult to retrieve otherwise |
| 6 | Use only one locking screw in the proximal fragment for distal and midshaft fractures | For more proximal fractures, use two proximal screws to prevent angular deformity |
| 7 | Identify specific implants in the operating notes, particularly special instruments | Will facilitate implant removal or revision |
| 8 | Perform aggressive IV or intramuscular pain management for 48 hours post-op | Use oral analgesia and avoid chronic narcotics after 14 days post-op |

Post-op, postoperatively; IV, intravenous.

***Table 4.*** Common failures, or "pitfalls," of nail insertion associated with retrograde nailing for treating femoral shaft fractures

| *Commonly failed actions* | *Details* |
|---|---|
| Confirming central position of the nail within a short distal fragment | Failure results in translational or angular malunion |
| Maintaining reduction while reaming | -- |
| Correctly mounting the nail on the insertion jig | -- |
| Identifying correct orientation/diameter of the interlocking guides, holes, and drill bit before insertion | To identify, perform a drop check |
| Striking only the drill insertion or extraction attachment with the mallet | Avoid striking the entire drill guide with the mallet |
| Over-reaming by 1 mm | Avoid using a nail of larger diameter than reamed |
| Advancing the nail with each blow | Failure may result in complications[a] |
| Using appropriate force advancing the nail | Excessive force may result in complicationsa |
| Maintaining rotation of the nail during insertion | Failure results in oblique malpositioned locking screws and fracture malreduction through loss of anatomical anterior bow |
| Maintaining reduction (especially length and rotation) during nail insertion | To ensure reduction is maintained, obtain sequential imaging if necessary |
| Confirming proper seating of the nail at the time of locking | Failure can lead to intra-articular prominence of the nail in knee joint |

--, not applicable.
[a]Complications include fracture comminution, propagation, and nail incarceration.

***Table 5.*** Pitfalls of locking associated with retrograde nailing for treating femoral shaft fractures

| *No.* | *Major Errors* | *No.* | *Technique Problems* |
|---|---|---|---|
| 1 | Not establishing a stable alignment for the limb, resulting in motion during locking screw placement and malposition of the screws | 7 | Allowing protrusion of screws beyond the distal femoral medial cortex, which will likely worsen symptoms |
| 2 | Improperly drilling a cortical hole near but not directly over the hole in the nail, making subsequent correct placement extremely difficult | 8 | Not removing the guide rod before drilling for locking screws |
| 3 | Placing screws that are too short, resulting in instability and angulation | 9 | Not fully seating the screw head against the near cortex, resulting in soft-tissue irritation |
| 4 | Failure to place both proximal and distal locking screws in rotationally or length unstable fracture patterns | 10 | Losing the screw from the screwdriver into the soft tissue during insertion[c] |
| 5 | Not assessing length, rotation, and stability at the end of the case[a] | 11 | Placement of locking screw in the wrong end of the dynamic slot[d] |
| 6 | Not assessing other injuries at the end of the case[b] | 12 | Attempting to use nail-mounted guides for distal locking, which are not reliable |

[a]This is the easiest time to correct any problems.
[b]Other injuries include femoral neck fractures and knee ligament injuries. Diagnoses are best at the end of the case to determine a plan of treatment.
[c]See pearl #5 in Table 3.
[d]For dynamic effect, place the screw in the end of the slot furthest from the fracture site.

***Table 6.*** Pitfalls of rehabilitation associated with retrograde nailing for treating femoral shaft fractures[12]

| *Commonly failed actions* | *Details* |
|---|---|
| Recognizing abnormal length or rotation during early ambulation | Relatively easy to correct by revision of the nail |
| Matching activity to the achieved stability and healing | Too much activity too soon can result in loss of fixation, fracture, or bending of nail[a] |
| Recognizing delayed union early | Earlier on, easiest to treat by simple dynamization |
| Prolonged use of narcotic analgesics | Failure can result in chronic dependency problems |

[a]But excessive restriction of activity can result in stiffness, weakness, and delayed union.

with retrograde nailing. Potential surgeon-related failures, or "pitfalls," associated with this approach include improper fracture choice (eg, femoral neck, intertrochanteric, and far proximal subtrochanteric fractures), incorrect entry point, malrotation, and failure to seat the nail sufficiently. Other pitfalls relating to nail insertion, locking errors, and rehabilitation are shown in Tables 4, 5, and 6, respectively.

## CONCLUSION

Retrograde nailing is an effective method for treating femoral shaft fractures. The technique is easier and requires less operating time than that of antegrade nailing, with equivalent outcomes.[13] Specific indications can be identified, for which retrograde nailing is theoretically preferred. The main pearls (Table 3) and pitfalls (Tables 4-6) have been outlined to aid the surgeon in achieving a successful radiological and functional outcome and avoiding problems when using the retrograde approach for treating femoral shaft fractures.

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