Technique Report

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# Distal femur: nail plate combination and the linked construct

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**Abstract**

**Summary:** Operative fixation of distal femur fractures in patients with osteoporotic bone can be challenging. Treatment with either lateral locking plate or retrograde intramedullary nail alone may not provide adequate fixation to allow for early mobilization. Rather, fixation using the nail plate combination (NPC) to treat distal femur fractures in the elderly may offer improved biomechanical stability to achieve immediate weight-bearing, especially in the setting of complex fracture patterns and osteoporosis. Here, we describe the rationale, step-by-step technique, and outcome following 2 cases: 1 patient treated with a true NPC procedure using retrograde intramedullary nail and standard locking plate, as well as a NPC procedure using a novel locking attaching washer plate.

**Keywords:** distal femur fracture, intramedullary nailing, locking plate, nail plate combination, retrograde

## 1. Introduction

As the elderly population continues to grow, the incidence of distal femur fractures is rising proportionally.[1] Historically, elderly patients presenting with distal femur fractures (native or periprosthetic) are treated with lateral locking plate (LLP) or retrograde intramedullary nail (rIMN), which demonstrate reliable outcomes as both methods have been shown to achieve equivalent union rates.[2,3] However, fixation with either of these constructs alone may not offer reliable enough biomechanical stability to allow for early mobilization and weight-bearing in patients with more complex fracture patterns, especially in the setting of osteoporosis.[4–8] Instead, fixation using nail-plate combination (NPC) may offer enhanced biomechanical stability to achieve immediate weight-bearing after surgery and reduced risk of fixation failure.[9–12]

The benefits of NPC arise from combining the biomechanical advantages of both LLP and rIMN constructs. The intramedullary nail shifts the stressful weight-bearing axis to the neutral, anatomic axis of the femur. However, IMN constructs have been found to sometimes be too flexible and therefore at risk of nonunion in osteoporotic bone. LLPs on the other hand bear all the force while the bone experiences much less stress.[7,8] In addition to combining the 2 with NPC, stable, enhanced fixation via the RFN-Advanced System with the Locking Attachment Washer (LAW, Depuy Synthes, West Chester, Pennsylvania) offers a focal density at the level of the joint line (most motion during ROM), while maintaining the neutral axis and inherent relevant stability conferred by the rIMN.

## 2. Case 1 description

This patient is a 75-year-old female who was approximately 10-months status-post open reduction internal fixation (ORIF) of the left distal femur performed at an outside institution. The patient had been kept non-weight bearing for 6 months and went on to develop a nonunion of the distal femur (Fig. 1A) prior to seeking out a second opinion. She was placed on a progressive weight-bearing protocol for the next 4 months. One day, the patient woke up with left thigh pain and was unable to ambulate. Radiographic imaging showed that the patient had developed a fracture through the nonunion with a hardware failure (Fig. 1B). This was a closed, isolated injury, and the patient remained neurovascularly intact.

Patient's medical history was significant for hypertension, dyslipidemia, depression, deep venous thrombosis, and lymphedema. As previously mentioned, her surgical history was significant for ORIF of her left distal femur that was performed at an outside institution approximately 10 months ago. The patient was medically optimized for surgical fixation of her left distal femur nonunion following a prophylactic course of apixaban for deep venous thrombosis prevention during the first 6 months of her non-weightbearing status following her index surgery.

## 3. Surgical considerations for standard NPC

There are a few important considerations to mention when using the standard NPC technique. First, the order of placement between nail or plate is inconsequential, although we prefer to place the nail

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**Figure 1.** AP x-ray of left knee demonstrating nonunion of distal femur with persistent fracture line on the medial side. There has been no additional varus or breaking of the plate and no signs of plate loosening at this time (A). AP x-ray of left knee demonstrating a distal femur fracture through the nonunion with a broken lateral locking plate (B). AP and lateral intraoperative fluoroscopic images of proximal and distal femur showing final fixation with standard NPC (C and D). AP and lateral x-ray of right knee at patient's 1-year postoperative office visit showing well-healed distal third femur fracture with maintained alignment (E and F).

first following provisional reduction of the fracture. Placing the nail first may expedite fixation by restoring and maintaining coronal and sagittal plane reduction for plate placement. Subsequent plate placement afterward would not only further maintain reduction, but also, more importantly, maintain length and rotation. Additionally, placing the plate after the nail also avoids the scenario where plate fixation screws end up being in the way of the nail and thereby hindering nail placement.

The length of the NPC construct is another important consideration. Our preference is to use a nail length that ends in between the calcar and the lesser trochanter to allow for a clear pathway for prophylactic femoral neck fixation from the plate. A shorter nail would leave an unbalanced modulus of fixation between the proximal and distal ends; additionally, ending a nail within the high-strain subtrochanteric area creates a risk for periprosthetic fracture. With regard to plate length, a 16-to 18-hole plate is deemed appropriate for most cases and custom-contoured to the patient's anatomy. With the use of a large plate bending press and "F" bending irons, a gentle curve may be placed on the proximal end of the plate. This bend would allow the plate to sit posteriorly and accommodate the anatomic curve of the vastus ridge while avoiding trochanteric impingement. This posterior bend would also help promote the appropriate anteversion needed for prophylactic screw placement into the femoral neck and head.

Bicortical purchase is preferred for distal fixation with at least 1 screw, preferably, linked through the plate and nail. The use of 2 screws is unnecessary but may be considered in the setting of significantly osteoporotic bone. An additional interlocking screw in the nail is also unnecessary if the density of fixation is achieved using 1 distal locking screw that, preferably, links the plate and the nail. Lastly, the use of at least 1 proximal locking screw in the nail is ideal. Two proximal locking screws may be considered in the setting of complex or wide spanning fractures in which increased resistance to torque is sought.

At the end of the surgery, multiple orthogonal fluoroscopic images were obtained to confirm appropriate screw length prior to wound closure (Fig. 1C and D). The patient was allowed to be full weight-bearing as tolerated immediately and was evaluated by physical therapy for ambulation and active range of motion exercises early throughout her postoperative course. At 1-year follow-up, the patient was completely clinically and radiographically healed with well-maintained alignment (Fig. 1E and F).

## 4. Case 2 description

This patient is a 57-year-old male who had sustained injury to his right leg after being struck by a car while walking to the

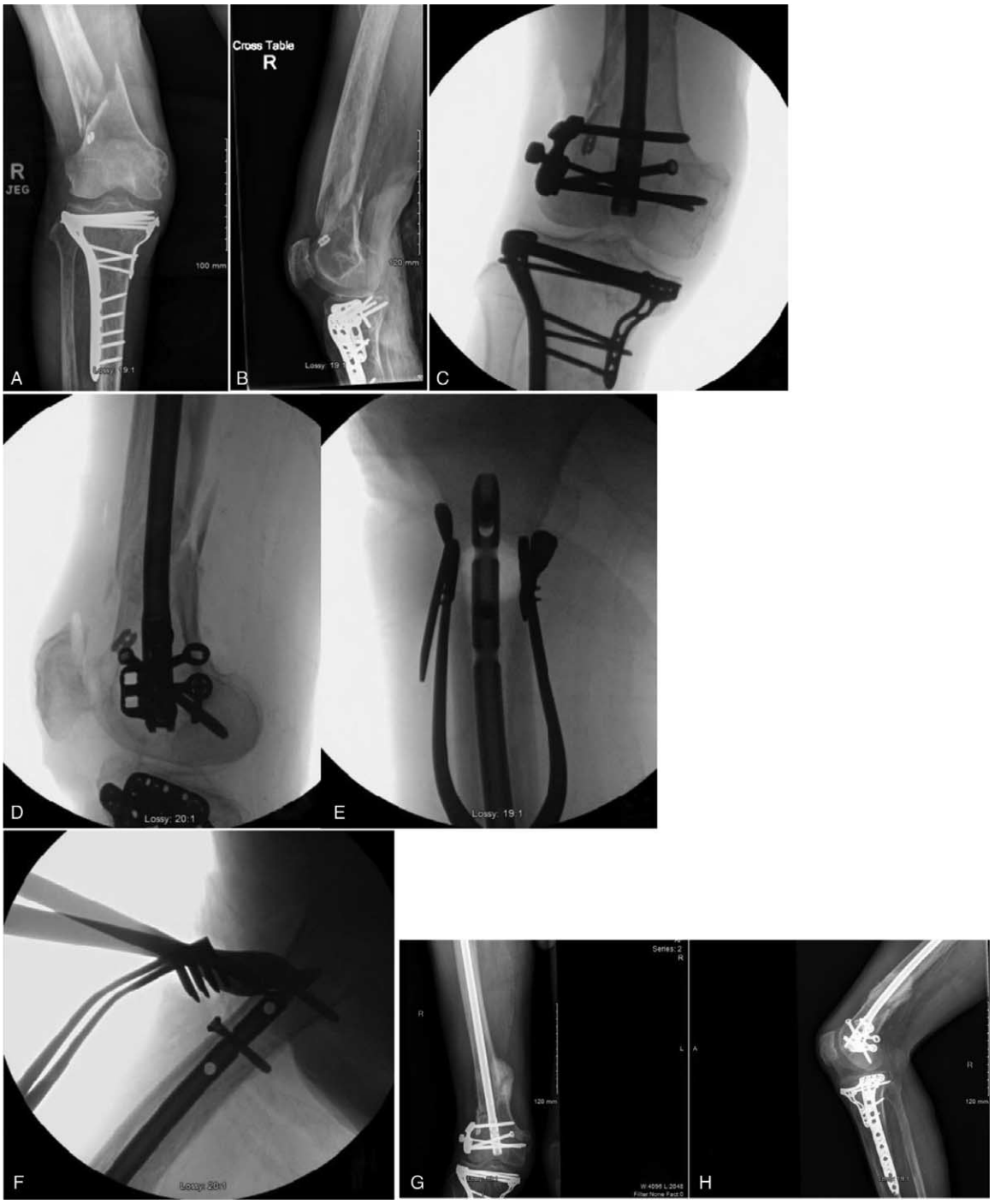


**Figure 2.** AP and lateral x-ray of right knee showing comminuted extra-articular distal third femur fracture (A and B). AP and lateral intraoperative fluoroscopic images of proximal and distal femur showing final fixation with rIMN and LAW (C-F). AP and lateral x-ray of right knee at patient's 6-month postoperative office visit showing well-healed distal third femur fracture with maintained alignment (G and H). LAW, locking attaching washer; rIMN, retrograde intramedullary nail.

laundromat. Initial radiographic imaging showed that the patient had sustained a closed extra-articular distal femur fracture (AO type A1 fracture) (Fig. 2A and B). Advanced imaging with computed tomography was performed and confirmed that there was no intra-articular extension, no Hoffa fragment, and no associated femoral neck fracture. The patient had no associated injuries.

The patient's medical history was significant for diabetes mellitus, end-stage renal disease on hemodialysis, hypertension, and dyslipidemia. His surgical history was notable for right anterior cruciate ligament reconstruction many years ago and ORIF of his right tibial plateau that had been performed at an outside institution 4 years prior. Once evaluated by nephrology and medically optimized, the patient was indicated for surgical fixation of his right distal femur fracture.

## 5. Surgical technique for LAW

Once the risks and benefits of the procedure were discussed at length with the patient and informed consent obtained, the

patient was brought to the operating room for planned rIMN utilizing the RFN-Advanced System with the LAW (DePuy Synthes, West Chester, Pennsylvania). This implant was selected as it allows for ease in obtaining unitized, fixed-angle fixation with the distal screws being inserted through both the LAW and the rIMN. The patient's medical history and known poor bone quality made the enhanced options for united distal fixation desirable.

The patient was placed supine on a radiolucent operating table with a bump placed under the ipsilateral buttock. C-arm was placed on the contralateral side for ease of obtaining intraoperative imaging. It is important to maintain exposure of the anterior superior iliac spine when prepping and draping, to allow for placement of proximal locking screws through the nail. A radiolucent triangle or sterile bump can be placed under the distal femur to function as both a reduction aid and to maintain knee flexion for nail insertion.

A 2-fingerbreadth midline skin incision was made from the inferior pole of the patella distally, and then a deep medial parapatellar incision was made. It should be noted that in the setting of periprosthetic fracture a larger midline incision can be used with a lateral parapatellar deep incision to evaluate the stability of the implant, to monitor the integrity of the polyethylene component, and to reduce the fracture prior to nail insertion. Once incisions had been made, the guidewire for the opening reamer was placed and position confirmed under both anterior-posterior and lateral fluoroscopic images. Opening reaming was then performed through a soft tissue protector.

From here reduction of the fracture was obtained and maintained prior to sequential reaming. For this case 2 anterior percutaneous incisions were made for the application of pointed reduction clamps at the fracture site. Once this provisional reduction was deemed satisfactory under fluoroscopy, the ball tipped guidewire was inserted to a position where the tip was just distal to the piriformis fossa proximally. The measuring gauge was then used to determine appropriate nail length and sequential reaming performed to 1.5 to 2 mm larger than the planned nail diameter.

Following nail insertion and guidewire removal, the targeting jig was attached, and an additional lateral incision was made from the distal aspect of the lateral femoral condyle about 4 fingerbreadths proximally, in line with the mid-axial line of the femur. Sharp incision of the iliotibial band and distal aspect of the vastus lateralis was made to place the LAW directly on bone. Cannulas were placed through the jig for 2 lateral-to-medial transverse distal locking screws, and the insertion handle was utilized to place the LAW in line with the cannulas. These holes were then drilled and two 5.0 mm distal locking screws were placed through the plate and the nail. An additional anteromedial to posterolateral screw was placed through the jig through the nail, and the additional tabs of the LAW were contoured to the patient's distal femur for 2 additional 3.5 mm locking screws to be placed through the plate. Finally, attention was turned to the proximal femur. Utilizing a free-hand, "perfect circle" technique, 2 anterior to posterior locking screws were placed through the nail (Fig. 2C-F).

At the conclusion of the procedure, multiple orthogonal fluoroscopic images were obtained to confirm appropriate screw length prior to closure. Due to the enhanced fixation in the distal fracture fragment, the patient was allowed to be full weight-bearing as tolerated immediately postoperatively. The patient was evaluated by physical therapy while in house for ambulation and active range of motion exercises of both hip and knee. At 6-month follow-up, the patient was completely clinically and radiographically healed with well-maintained alignment (Fig. 2G and H).

## 6. Discussion

Operative fixation with an integrated NPC construct in the treatment of native or periprosthetic distal femur fractures offers promising outcomes.[9–12] It is ideal for geriatric patients presenting with osteoporotic distal femur fractures who are ambulatory at baseline and require immediate weight-bearing to prevent morbidity and mortality.[9] Liporace and Yoon retrospectively reviewed a case series of 15 patients who underwent NPC for acute native or periprosthetic distal femur fractures (average follow-up $19.2 \pm 6.7$weeks) and found that all of their patients healed without infection, nonunion, or hardware failures, and that they all remained ambulatory.[9] The idea behind the technique is that the nail and plate combination increase points of fixation and creates a fixed angle construct while shifting the weight-bearing axis more medially along the anatomic axis of the femur, thus conferring increased bio-mechanical stability with benefits of both nailing and plating. This allows for confidence in early weight-bearing and mobilization to reduce subsequent complication risk.

In the case of our second patient presentation, the NPC technique with the use of the RFN-Advanced System with the LAW provides up to 7 points of fixation at the distal femur in a unitized fashion to achieve stability and promote immediate mobilization. Additionally, the multiple offerings of the distal anterior-to-posterior bend of this particular rIMN help prevent implant-related sagittal plane deformation, especially when customizing the implant to atypical anatomy or pre-existing implants.[12] Furthermore, the NPC construct may be used to achieve stable fixation and confer early weight-bearing over LLP or rIMN fixation alone in patients with broader, more complex fracture patterns, as well as patients who present with poor bone quality, comminution, and lack of intramedullary nail cortical contact.

## 7. Conclusions

Treatment of native or periprosthetic distal femur fractures in the setting of complex fracture patterns and osteoporosis can be challenging. Operative fixation with LLP or rIMN alone may require protected weight-bearing due to their limited bio-mechanical strength, while integrated NPC constructs allow for enhanced biomechanical stability, promote immediate weight-bearing, and reduce complication risk. However, biomechanical studies using finite element analysis are still needed to confirm the theoretical benefits of NPC. While the technique is reliable, efficient, and reproducible, with promising early results, larger comparative studies are still required to confirm these findings and determine whether there is any clinical benefit. If clinical outcomes using NPC are indeed favorable, future studies should then also consider performing cost analyses to justify the increased cost of using a united construct for early mobilization.

## References

1. Della Rocca GJ, Leung KS, Pape HC. Periprosthetic fractures: epidemiology and future projections. *J Orthop Trauma* 2011; 25: S66–S70.
2. Jankowski JM, Szukics PF, Shah JK, et al. Comparing intramedullary nailing versus locked plating in the treatment of native distal femur

fractures: is one superior to the other? *Indian J Orthop* 2021; 55:646–654.
3. Shah JK, Szukics P, Gianakos AL, Liporace FA, Yoon RS. Equivalent union rates between intramedullary nail and locked plate fixation for distal femur periprosthetic fractures—a systematic review. *Injury* 2020; 51:1062–1068.
4. Bong MR, Egol KA, Koval KJ, et al. Comparison of the LISS and a retrograde-inserted supracondylar intramedullary nail for fixation of a periprosthetic distal femur fracture proximal to a total knee arthroplasty. *J Arthroplasty* 2002; 17:876–881.
5. Kregor PJ, Stannard JA, Zlowodzki M, Cole PA. Treatment of distal femur fractures using the Less Invasive Stabilization System: surgical experience and early clinical results in 103 fractures. *J Orthop Trauma* 2004; 18:509–520.
6. Ricci WM, Streubel PN, Morshed S, Collinge CA, Nork SE, Gardner MJ. Risk factors for failure of locked plate fixation of distal femur fractures: an analysis of 335 cases. *J Orthop Trauma* 2014; 28:83–89.
7. Salas C, Mercer D, DeCoster TA, Reda Taha MM. Experimental and probabilistic analysis of distal femoral periprosthetic fracture: a comparison of locking plate and intramedullary nail fixation. Part B: probabilistic investigation. *Comput Methods Biomech Biomed Engin* 2011; 14:175–182.
8. Salas C, Mercer D, DeCoster TA, Reda Taha MM. Experimental and probabilistic analysis of distal femoral periprosthetic fracture: a comparison of locking plate and intramedullary nail fixation. Part A: experimental investigation. *Comput Methods Biomech Biomed Engin* 2011; 14:157–164.
9. Liporace FA, Yoon RS. Nail plate combination technique for native and periprosthetic distal femur fractures. *J Orthop Trauma* 2019; 33:E64–E68.
10. Liporace FA, Aneja A, Carroll EA, Yoon RS. Maintaining the neutral axis in the treatment of distal femur fractures via dual plate or nail plate combination technique: when and how? *J Orthop Trauma* 2021; 35: S38–S40.
11. Yoon RS, Patel JN, Liporace FA. Nail and plate combination fixation for periprosthetic and interprosthetic fractures. *J Orthop Trauma* 2019; 33: S18–S20.
12. Liporace FA, Menken LG, Yoon RS. Complex distal femur fracture: a new and novel technique to maximize fixation and promote early weight-bearing—a case report. *J Orthop Trauma* 2021; 35:e1–e4.