

Research Articles

Comparison of Short-Term Clinical Outcomes of the DePuy Synthes Femoral Reconstruction Nail with the Synthes Expert Retrograde/Antegrade Femoral Nail for Intramedullary Nailing in Femoral Shaft Fractures

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Objectives

The objective of this study is to compare the complications, rates of reoperation, and related secondary measures between two devices used to manage femoral shaft fractures: the DePuy Synthes Femoral Recon Nail (FRN) and its predecessor, the DePuy Synthes Expert Retrograde/Antegrade Femoral Nail (R/AFN). The primary null hypothesis was that the two devices had no significant difference in the clinical outcomes. Our secondary hypothesis was that there is no significant difference in the duration of surgery between the two devices.

Methods

This study reviewed charts of all patients aged 18-89 who underwent antegrade intramedullary nailing for a femoral shaft fracture, subtrochanteric femur fracture, or a combined femoral neck/shaft fracture with either a FRN or a R/AFN from January 1st, 2010, to April 1st, 2022, at a single level 1 trauma center. A total of 88 subjects were identified for study inclusion: 30 patients who underwent fixation with the R/AFN system and 58 patients who received treatment with the FRN system. These subjects' charts and radiographs were then analyzed for patient characteristics, fracture characteristics, radiographic outcomes, and clinical outcomes. Statistical significance between variables was ascertained using chi-squared analysis and t-tests. Significant results were confirmed via power analysis with a two-sample t-test and normalization for demographic differences using linear regression.

Results

Average body mass indexes (BMIs) were 24.6 ± 4.4 kg/m² and 27.9 ± 4.6 kg/m² for the R/AFN and FRN groups, respectively ($P=.002$). The duration of surgery was 2.4 ± 1.0 hours for the R/AFN cohort and 3.1 ± 1.1 hours for the FRN cohort ($P=.01$). No statistically significant differences were found in the clinical outcomes between the two devices.

Conclusion

The FRN has short-term clinical outcomes comparable to the R/AFN in terms of safety and efficacy.

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INTRODUCTION

Femoral shaft fractures are a commonly seen injury after high-impact trauma, such as a motor vehicle collision (MVC) or motorcycle accident.¹ The most common surgical method to address this fracture type is intramedullary nailing.²

Intramedullary nailing is a well-studied fixation technique that has been shown to have good outcomes in most patients.³ As the technique has evolved, three common surgical entry points have emerged: piriformis fossa, the tip of the greater trochanter, and retrograde nailing.⁴ Antegrade nailing procedures utilize both the piriformis fossa and tip of the greater trochanter entry points, and nails have been designed with these entry points in mind. While these implants vary in their biomechanical properties, several studies have shown little difference in outcomes between the piriformis fossa and the tip of the greater trochanter entry points.⁵⁻⁷ Some merits of the greater trochanteric approach are that it produces less soft tissue damage upon entry^{8,9} and is easier to access.^{7,10} The piriformis fossa approach remains in use today because it is in a straight line with the intramedullary canal, which can minimize complications from deformity in certain fracture patterns.^{3,5-7,9} However, despite the relative merits of each approach, neither is definitively superior from a patient-outcome perspective.

Advancements in femoral nailing implants have also evolved. Newer implants are designed to reduce surgical complications and address newer concepts in fixation, such as prophylactic femoral neck fixation.¹¹ Studies have found that not all alterations to nail design are improvements. However, some reports indicate a higher nonunion rate after treatment with reconstruction nails.¹²

The DePuy Synthes Femoral Recon Nail (FRN) differs from the older DePuy Synthes Expert Retrograde/Antegrade Femoral Nail (R/AFN) in that it has both piriformis fossa and greater trochanteric entry designs and multiple proximal locking options. In contrast, the R/AFN is designed to enter only the piriformis fossa. This retrospective clinical comparison between the FRN and the R/AFN aims to provide valuable insights into their relative safety and efficacy in treating femoral fractures through analysis of complications, rates of reoperation, and related secondary measures. By analyzing real-world outcomes, we hope to guide clinical decision-making, optimize patient care, and contribute to the growing orthopedic literature on fracture management.

MATERIALS AND METHODS

STUDY DESIGN

This study is an internal review board (IRB) approved retrospective chart review of all patients ages 18-89 who underwent antegrade intramedullary nailing for a diaphyseal (shaft) femoral fracture, subtrochanteric femur fracture or a combined femoral neck/shaft fracture with either a FRN or a R/AFN from January 1st, 2010, to April 1st, 2022, at a single level 1 trauma center. Of the initially identified

730 subjects, 642 subjects were eliminated based on the following criteria: intertrochanteric fracture/other fracture not of study (n=71), retrograde nailing approach (n=194), other intramedullary nailing equipment/fixation technique (n=175), prior ipsilateral femur fracture/deformity (n=13), less than three months of documented follow up visits (n=166), age less than 18 or greater than 89 (n=19), prisoners (n=3), and one patient who passed away before surgery (n=1). Pregnancy was also an exclusion criterion, but no pregnant patients were in this group. A total of 88 subjects were identified for study inclusion: 30 patients who underwent fixation with the R/AFN system and 58 patients who received treatment with the FRN system. The choice of approach (trochanteric versus piriformis entry) for the FRN system was at the surgeon's discretion. These subjects' charts and radiographs were then analyzed for patient and fracture characteristics and clinical outcomes. Preliminary external fixation was recorded for its potential role as an extraneous variable.

PATIENT CHARACTERISTICS

The characteristics of the selected cohort were extracted: age, sex, gender, ethnicity, smoking history, mechanism of injury, body mass index (BMI), presence of additional injuries, and comorbidities. Gender was classified as male or female; ethnicity as African American, Hispanic, or Non-Hispanic; smoking status as current, never, or quit; and mechanism of injury as low impact (i.e., mechanical fall from standing height) or high impact (i.e., MVC, struck by a train, or fall from above standing height). Comorbidities that were recorded include hypertension (HTN), hyperlipidemia (HLD), diabetes, chronic kidney disease/injury (CKD), osteoarthritis, autoimmune disorders, vitamin D deficiency, hypocalcemia, and drug/substance abuse [Tables 1 and 2].

FRACTURE CHARACTERISTICS

Preoperative radiographs were analyzed for fracture classification according to the Revised AO/OTA classification system (January 2018).¹³ Of the 88 fractures, 5 were classified as 32A1, 12 as 32A2, 16 as 32A3, 2 as 32B2, 24 as 32B3, 6 as 32C1, 5 as 32C2, and 18 as 32C3 [Table 3].

RADIOGRAPHIC OUTCOMES

Delayed union and non-union of fractures were determined by the lack of interval callus formation after three and six months, respectively. Fractures were considered healed when patients could bear weight without thigh pain, and radiographs showed bridging callus.¹⁴

CLINICAL OUTCOMES

Clinical outcomes were assessed via a review of the electronic medical records. We included the duration of surgery, estimated blood loss during surgery, postoperative time until weight-bearing, and the incidence of complications, including infection, malalignment, malrotation, bro-

Table 1. Demographics of study participants.

Demographics	R/AFN N=30	FRN N=58	Total N=88	P-Value
Age (years)	33±13	35±16	34±15	0.53
BMI (kg/m ²)	25±4.4	28±4.6	27±4.8	0.002
Male	23 (77%)	46 (79%)	69 (78%)	0.78
Female	7 (23%)	12 (21%)	19 (22%)	
African American	21 (70.%)	34 (59%)	55 (63%)	0.81
Hispanic/Latino	7 (23%)	16 (28%)	23 (26%)	
White	1 (3.3%)	3 (5.2%)	4 (4.5%)	
Not reported	0 (0.0%)	2 (3.4%)	2 (2.3%)	
Other	1 (3.3%)	2 (3.4%)	3 (3.4%)	
More than one race	0 (0.0%)	1 (1.7%)	1 (1.1%)	
Current smoker	14 (47%)	26 (45%)	40 (46%)	0.96
Former Smoker	4 (13%)	8 (14%)	12 (14%)	
Never smoker	11 (37%)	23 (40.%)	34 (39%)	
Unknown Smoking Status	1 (3.3%)	1 (1.7%)	2 (2.3%)	
HTN	3 (10.%)	11 (19%)	14 (16%)	0.28
HLD	2 (6.7%)	3 (5.2%)	5 (5.7%)	0.77
CKD	1 (3.3%)	2 (3.4%)	3 (3.4%)	0.98
Osteoarthritis	0 (0.0%)	4 (6.9%)	4 (4.5%)	0.14
Autoimmune disease	0 (0.0%)	2 (3.4%)	2 (2.3%)	0.3
Diabetes Mellitus	0 (0.0%)	3 (5.2%)	3 (3.4%)	0.2
Vitamin D deficiency	3 (10.%)	3 (5.2%)	6 (6.8%)	0.39
Hypocalcemia	0 (0.0%)	1 (1.7%)	1 (1.1%)	0.47
Drug/alcohol abuse	5 (16.7%)	3 (5.2%)	8 (9.1%)	0.075

Table 2. Injury Characteristics.

Injury Characteristics	R/AFN N=30	FRN N=58	Total N=88	P-value
Total number of nailing procedures	30 (100%)	58 (100%)	88 (100%)	N/A
Right-sided fractures	15 (50.%)	31 (53%)	46 (52%)	0.76
Left-sided fractures	15 (50.%)	27 (47%)	42 (48%)	
High energy injury	29 (97%)	53 (91%)	82 (93%)	0.35
Low energy injury	1 (3.3%)	5 (8.6%)	6 (6.8%)	
Major associated injury	12 (40.%)	34 (83%)	46 (79%)	0.25
Minor associated injury	5 (17%)	7 (17%)	12 (21%)	
No associated injury	13 (43%)	17 (29%)	30 (34%)	

ken screw(s), reoperation, deep venous thrombosis (DVT), pulmonary embolism (PE), nerve injury, heterotopic ossification, and other complications [Tables 4, 5, and 6]. In conclusion, short-term outcomes were defined as clinical outcomes occurring within the maximum follow-up time for patients in this study.

STATISTICAL METHODS

Statistical significance was ascertained using chi-squared analysis and t-tests. Chi-squared analysis and t-tests were initially used to determine whether the R/AFN cohort was

similar to the FRN cohort in the following demographic variables: gender, race, risk factors, comorbidities, BMI (kg/m²), etc. In addition, these analyses were used to determine whether the nailing system had a significant effect on intra-operative and post-operative complications such as duration of surgery (minutes), length of follow-up (days), blood loss (ml), post-operative days until weight-bearing as tolerated (days), infection, nonunion/delayed union, malalignment/malrotation, broken screw(s), heterotopic ossification, nerve injury, and other complications. Any significantly different results between the two groups were

Table 3. Fracture Characteristics.

Fracture characteristics	R/AFN N=30	FRN N=58	Total N=88
32A1	0 (0%)	5 (8.6%)	5 (5.7%)
32A2	6 (20%)	6 (10.%)	12 (14%)
32A3	4 (13%)	12 (21%)	16 (18%)
32B2	0 (0%)	2 (3.4%)	2 (2.3%)
32B3	12 (40%)	12 (21%)	24 (27%)
32C1	0 (0%)	6 (10.%)	6 (6.8%)
32C2	2 (6.7%)	3 (5.2%)	5 (5.7%)
32C3	6 (20%)	12 (21%)	18 (20.%)

Table 4. Operative Measures.

Operative measures	R/AFN N=30	FRN N=58	Total N=88	P-value
Preliminary external fixator	2 (6.7%)	11 (19%)	13 (15%)	0.12
Duration of surgery (hours)	2.4±1.0	3.1±1.1	2.9±1.2	0.01
Blood loss (mL)	281±197	431±516	380±439	0.053
Length of follow-up (days)	467±425	260±224	331±321	0.017
Post-operative days for weight bearing as tolerated (days)	40.±33	51±35	47±35	0.14
Greater trochanter entry portal	0	39	39	N/A
Piriformis fossa entry portal	30	19	49	

Table 5. Operative and Post-Operative Complications.

Operative complications	R/AFN N=30	FRN N=58	Total N=88	P-value
Major vascular injury	0 (0%)	0 (0%)	0 (0%)	N/A
Stroke	0 (0%)	0 (0%)	0 (0%)	
Cardiac arrest	0 (0%)	0 (0%)	0 (0%)	
Iatrogenic fracture	0 (0%)	0 (0%)	0 (0%)	
Post-operative complications	R/AFN N=30	FRN N=58	Total N=88	P-Value
Infection	2 (6.7%)	3 (5.2%)	5 (5.7%)	0.77
Delayed/nonunion	1 (3.3%)	1 (1.7%)	3 (3.4%)	0.23
Malalignment/malrotation	1 (3.3%)	1 (1.7%)	2 (2.3%)	0.63
Broken screw	3 (10.0%)	1 (1.7%)	4 (4.5%)	0.08
DVT	0 (0.0%)	1 (1.7%)	1 (1.1%)	0.47
PE	0 (0.0%)	3 (5.2%)	3 (3.4%)	0.2
Nerve Injury	2 (6.7%)	5 (8.6%)	7 (8.0%)	0.75
Heterotopic Ossification	2 (6.7%)	3 (5.2%)	5 (5.7%)	0.77
Other post-op complications	3 (10.0%)	1 (1.7%)	4 (4.5%)	0.08
Reoperation	6 (20.0%)	5 (8.6%)	11 (12.5%)	0.13

then further analyzed. A power analysis via a two-sample t-test with unequal sample sizes and a linear regression model that controlled for any demographic variables found to be different between the two groups was used.

RESULTS

Of the 88 subjects in our cohort, 19 were female, and 69 were male. The mean age was 34 years old. The mean follow-up time for the entire cohort was 331 days, with a standard deviation of 321 days.

Demographic information is contained below [Table 1]. BMI was the only demographic information found to be statistically significant between the R/AFN and FRN cohorts, with an average BMI of 25 ± 4.4 kg/m² and 28 ± 4.6 kg/m², respectively ($P=.002$) [Table 1]. Fracture and injury characteristics were not significant [Tables 2 and 3]. As BMI was found to be a statistically significant demographic difference between the two groups, further analysis for potential differences in outcomes between the two groups was controlled for this demographic.

Every R/AFN nail was inserted via the piriformis fossa, while 39/58 FRN nails (67%) and 19/58 (33%) were inserted via the tip of the greater trochanter and piriformis fossa, respectively. The mean blood loss for the R/AFN cohort was 281 ± 197 mL and 431 ± 516 mL for the FRN cohort ($P=0.053$). While not a statistically significant result, the difference in blood loss is still notable [Table 4].

Duration of surgery and length of follow-up were both found to be statistically different between the two cohorts. The average length of surgery was 2.4 ± 1.0 hours for the R/AFN cohort and 3.1 ± 1.1 hours for the FRN cohort ($P=0.01$) [Table 4]. This result held true when controlled for the BMI demographic ($P=0.03$). Additionally, it was found to be adequately powered at 80%. The average follow-up length was 467 ± 425 days for the R/AFN cohort and 260 ± 224 days for the FRN cohort ($P=0.017$) [Table 4]. The maximum follow-up length among all patients was 1534 days. Like the duration of surgery, this result also held true when controlled for BMI ($P=0.003$). However, it was not an outcome that was adequately powered at only 57%.

No intraoperative complications were noted. Post-operative complications were not found to be statistically significant [Table 5]. Further results provide a complete recounting of all post-operative complications and are seen as an appendix to this paper [Table 6-Supplemental].

DISCUSSION

This retrospective review compared the short-term clinical outcomes of the R/AFN to the newer FRN. Per length of follow-up results, short-term can be officially defined as any complication occurring within 1,534 days (4.2 years) of the operation. Based on our analysis, the FRN performed similarly to the R/AFN nail in both intraoperative and clinical outcomes.

While the analysis of the demographic data between the R/AFN and FRN cohorts did demonstrate a statistically significant difference in BMI and duration of surgery, our analysis showed no statistically significant difference in post-operative outcomes between the FRN and R/AFN nails. The demographic differences may indicate that surgeons at this institution preferred the FRN for patients with increased BMI compared to other studies, which showed no variation in BMI.^{5,11} Additionally, the increased mean blood loss and operative time for the FRN cohort may suggest that this system was selected for more challenging cases due to its capacity to act as a reconstruction nail.^{5,7,11,12,15}

Furthermore, there was an observed difference between the length of follow-up between the R/AFN and FRN cohorts, with the R/AFN having an average follow-up time of 206.9 days longer than the FRN group. Similar results were seen in the literature.^{12,14,15} However, since this variable's comparison was underpowered, we cannot make any conclusions about this result. Because of this, it should be noted that the length of follow-up would be good to keep in mind for future studies comparing these two techniques, as there may be a difference that could lead to a conclusion with a larger sample size.

When comparing the results of this study to literature values of complication rates for intramedullary and cephalomedullary nails, little discrepancy is observed. The results of this study demonstrated an infection rate of 6.7% for the R/AFN system and 5.2% for the FRN system, which agrees with literature values of <10%.^{3,14} This study found that 3.3% of the R/AFN cohort and 1.7% of the FRN cohort experienced delayed/nonunion. This again agrees with literature values of approximately .9%.³ Literature rates of malalignment and malrotation are roughly 9%,¹⁶ which is above what was observed in this study, with 3.3% of the R/AFN group and 1.7% of the FRN group demonstrating this complication. Respiratory complications, including PE, were as high as 10% in the literature,³ whereas 0% of the R/AFN subjects and 1.7% of the FRN subjects experienced PE. Reoperation rates were notably lower in the literature, with some studies reporting only 2.9-3.2%,¹⁵ whereas our study documented 20.0% in the R/AFN cohort and 8.6% in the FRN cohort. The overall broken screw rate was 4.5% which is in line with literature incidence rates of 0-8%.^{17,18} Literature values of mean operative time ranged from 1.46 to 1.76 hours, lower than the 2.4 and 3.1 hours observed for the R/AFN and FRN groups, respectively. This study and the literature share similar mean blood loss values, with some studies reporting a range of 100-700mL,^{11,20} which agrees with our values of 281mL and 431mL for the R/AFN and FRN groups, respectively.

The lower rate of broken screws observed for the FRN, although not statistically significant, may be due to improved nail or screw design or a unique load profile that mitigates overloading of screws. However, since this was a retrospective study with inherent limitations, this could also be due to postoperative patient activity, differences in weight-bearing restrictions, or other confounding variables. A biomechanical investigation could clarify if there are any specific differences in the constructs that could lead to our observation. It is also worth noting that not all broken screws were symptomatic or required removal or exchange.

While reoperation rates did not significantly differ between nail types in our study, it is worth discussing the qualitative trends in reoperations between the different systems.¹⁵ Overall, the FRN system's reoperations were more diverse, with a slight preference for irrigation and debridement (I&D) and removal of symptomatic hardware. Patients who underwent reoperation with the R/AFN system were more clustered around symptomatic hardware removal, I&D, and hardware revision. Most of the revisions/

hardware removals in the FRN cohort were usually due to infection, while many of the hardware removals in the R/AFN subjects were due to issues with screws.^{17,18} Although this study found no statistical difference between reoperation rates in these two systems, this discrepancy may be an interesting foundation for a future biomechanical study comparing these two nails.

The lack of statistically significant differences in post-operative outcomes between the FRN and R/AFN nails would suggest that both implants can be used safely.^{3,11,14-18} Based on this study's findings, surgeon preference, and operative indications should guide the decision regarding which implant to use, as there seems to be no objective difference in safety data. The FRN functions as a cephalomedullary nail, which may provide additional utility in specific fracture patterns, while the R/AFN is an intramedullary nail that can be used in a retrograde approach as well. Although this study did not investigate the retrograde facet of the R/AFN nail, it is important to note this component of its utility when selecting implants for fixation.

As noted above, this investigation has several shortcomings due to its retrospective design. The lack of patient-oriented outcome measures did not allow us to assess pain and function. A prospective design, in addition to including patient-reported outcomes, would be helpful for these purposes. The small numbers in this case series are also a shortcoming that could be improved by including additional investigational sites. In addition, the low population size of our study left our data susceptible to outliers and made our findings difficult to generalize.

Shortcomings aside, there are some advantages to the consistency of single-center data reporting. There are also

no other known reports of a direct clinical comparison of the FRN with the R/AFN, so we believe that this study demonstrates a degree of safety and short-term efficacy of the newer device.

CONCLUSION

The FRN has short-term clinical outcomes comparable to the R/AFN in terms of safety and efficacy.

DECLARATION OF CONFLICT OF INTEREST

The authors do NOT have any potential conflicts of interest for this manuscript.

DECLARATION OF FUNDING

Funding was received from Depuy Synthes CMF.

DECLARATION OF ETHICAL APPROVAL FOR STUDY

Ethical approval was obtained for this study by an institutional review board, IRB# 25916, approved on 6/10/19 and 5/19/23.

DECLARATION OF INFORMED CONSENT

There is no information (names, initials, hospital identification numbers, or photographs) in the submitted manuscript that can be used to identify patients.

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SUPPLEMENTAL MATERIALS

Table 6. Detailing of Specific Post-Operative Complications by Case.

Patient number	Nail type	Complication(s)	Details and treatment
1	FRN	Delayed union/ Nonunion	The fracture did not heal at 9.5 months postop; planned for nonunion repair, but the patient lost to follow-up
4	FRN	Screw loosening or breakage	The fracture healed; the interlocking screw backed out slightly on imaging but was not clinically symptomatic
5	FRN	Other	The patient had initial bilateral external fixation, then had right femur and left tibia nailing. Underwent bilateral knee manipulation at 2.5 months postop for knee stiffness.
8	RAFN	Nerve injury	Had gunshot injury with foot drop seen on initial presentation preoperatively. The patient was lost to follow-up at three months
9	RAFN	Infection	Sustained gunshot injuries with an open fracture. Developed deep infection requiring debridement, hardware removal, antibiotic spacer rod placement, and eventual rod removal. Fracture healed
10	RAFN	Screw loosening or breakage	It developed shortening of the fracture two months post-op with backing out of screws distally. This underwent revision of distal locking screws and bone graft substitute injection to improve fixation of the screws.
11	RAFN	Other	The patient developed back pain, lumbar degenerative disc, and facet disease. The pain developed after the injury (MVC), and eventually sought treatment six months later and was treated with physical therapy. The patient was lost to follow-up after that.
12	RAFN	Screw loosening or breakage, Nerve injury	The patient developed broken interlocking screws at two months postop. The fracture was healing but incompletely at three months. The patient was seen again four years later after the fracture had healed. The patient was noted to have persistent neuropathic pain.
13	RAFN	Heterotopic ossification	The fracture had minimal callus at early follow-up but did eventually heal. The patient had some mild heterotopic ossification at the entry site, but this was not symptomatic.
14	RAFN	Screw loosening or breakage, Infection	The fracture was incompletely healed at 4 months postop with a broken screw. The patient was then lost to follow-up until three years later, at which point the fracture was healed. Infected screws were noted and were treated with incision and drainage and screw removal.
15	RAFN	Other	The patient developed numbness likely from lumbar disk degeneration and stenosis, was sent to get an MRI scan, and was then lost to follow-up.
18	FRN	PE	The patient was treated medically for PE.
19	FRN	Malalignment	The intramedullary nail was inserted with excessive internal rotation of the nail, creating a medial bowing. The fracture was healing when the patient followed up in the clinic with no significant clinical complaints or deformity.
20	FRN	Nerve injury	The patient sustained a gunshot injury with a foot drop noted before intramedullary nailing. This foot drop eventually resolved spontaneously.
21	FRN	Heterotopic ossification	The patient developed heterotopic ossification at one of the thigh external fixator pin sites. The patient did not seek surgical intervention for this.
22	FRN	Heterotopic ossification	The patient had a Morel Lavallee lesion requiring early incision and drainage procedures. The patient had initial external fixation as well as pelvic and acetabular fractures requiring ORIF. The patient also had heterotopic ossification near the nail portal site that did not require surgical intervention.
23	FRN	Heterotopic ossification	The patient underwent thigh fasciotomy that required multiple I&D procedures. The patient also underwent ORIF of an ipsilateral acetabulum fracture. The patient developed heterotopic ossification of the nail portal site and the thigh at the external fixation pin sites. This was treated with excision of heterotopic ossification and quadriceps release.
24	FRN	PE	PE treated medically.
25	FRN	Infection	The patient sustained a gunshot open femoral shaft fracture. This developed a deep infection requiring removing the intramedullary nail and placing an antibiotic cement rod. The patient was then lost to follow-up
26	FRN	Nerve injury	The patient sustained a gunshot injury resulting in a foot drop noted before surgery. The foot drop resolved spontaneously.
27	FRN	PE	PE treated medically.

Patient number	Nail type	Complication(s)	Details and treatment
28	FRN	Infection	The patient underwent intramedullary nailing and was lost to follow-up. Four years later, the patient developed severe frostbite, resulting in bilateral below-knee amputations and eventually an above-knee amputation in which the nail was cut with the femur. The patient eventually developed stump wound complications and an infected femoral nail. This was treated with removal of the implants and debridement of the femur.
30	RAFN	Malalignment, Nonunion	The patient had rotational malalignment that was treated with a revision of the interlocking screws. The patient also later developed nonunion, requiring nonunion repair.
32	FRN	Nerve injury	The patient had a gunshot injury to the thigh and had ongoing thigh paresthesia at the final follow-up that was treated conservatively.
34	FRN	Infection, DVT	The patient developed a deep infection that ultimately required implant removal. Also, the patient developed a DVT that was treated medically.
35	RAFN	Other	The patient developed painful hardware from the medial tip of the distal locking screw. This required removal of a distal interlocking screw, after which symptoms resolved.
36	RAFN	Delayed union/nonunion	The patient was noted to have a delayed union at five months, which was treated with dynamization by screw removal distally. After this, the fracture healed.
37	RAFN	Heterotopic ossification	The patient was noted to have some heterotopic ossification at the posterolateral proximal femur near the starting point of the nail. This improved without surgical treatment.
38	FRN	Nerve injury	The patient sustained a gunshot injury. The patient was diagnosed with femoral nerve injury, confirmed on electromyogram, but this spontaneously resolved.
39	FRN	Nerve injury	The patient sustained a gunshot injury with a foot drop noted preoperatively. An electromyogram noted sciatic nerve injury at the level of gunshot injury. This eventually resolved spontaneously.

This table lists complications for each patient. Some patients have multiple complications. Some of these complications were treated with reoperations listed in the fourth column.