RESEARCH ARTICLE

Knee Pain and Functional Outcomes after Retrograde Femoral Nailing: A Retrospective Review

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Abstract

Objectives: To investigate the incidence and severity of knee pain following retrograde intramedullary nailing of femur fractures and to better understand functional outcomes using validated patient-reported outcome measures.

Methods: Fifty-three patients with OTA 32 or 33 fractures treated by retrograde nail at a single academic Level 1 trauma center between 2009 and 2020 were retrospectively reviewed. Patients verbally completed the Oxford Knee Score (OKS) and Patient-Reported Outcome Measurement Information System (PROMIS) Short Form 6b, minimum one year postoperatively.

Results: Thirty-four (64%) patients reported the presence of pain. Of those reporting pain, 16 (47.1%) reported their pain as mild. Compared to those without pain, patients with knee pain had lower OKS (30.38 +/- 10.65, versus 41.95 +/- 6.87; P <0.001) and higher PROMIS scores (14.65 +/- 6.76 versus 10.95 +/- 7.09; P=0.066).

Conclusion: The increasing severity of pain was inversely correlated with functional status as measured by patient-reported measures. At present, the reliability, high union rates, and otherwise low complication rates associated with retrograde femoral nailing justify its continued use. However, knee pain and functional outcomes should remain an integral part of the preoperative discussion with the patient.

Level of evidence: III

Keywords: Function, Femur, Intramedullary nail, Knee, Pain, Retrograde, Trauma

Introduction

Femoral shaft fractures have a national annual incidence of 10 to 21 per 100,000 individuals, with bimodal distribution peaking among younger males and older females.[1,2] These injuries demonstrate bimodal distribution with peaks in incidences among younger males (15 – 35 years) and older females (greater than 60 years).[1] Femoral shaft fractures in young males are often attributed to high-energy trauma, including motor vehicle collisions, falls from height, and gunshot wounds. In contrast, older females sustain this injury secondary to low energy mechanisms such as falls from standing height, often in the setting of underlying osteoporosis.[1,2] Factors that determine surgical management of femoral fractures include the location of the fracture, degree of comminution, presence of concomitant injuries, and preoperative functional status.[1] Intramedullary nailing is often favored as these devices are load-sharing, require less soft-tissue stripping, and allow for earlier mobilization.[1,3-6] Antegrade femoral nailing has demonstrated excellent outcomes in the literature with regard to fracture union and early postoperative mobilization. Antegrade nailing, however, is associated with several complications, including Trendelenburg gait, persistent hip pain, and iatrogenic femoral neck fracture.[7-14] Retrograde femoral nailing has been shown to be a safe alternative to antegrade nailing, especially in bilateral or distal femur fractures, ipsilateral femoral neck or tibia fractures, obesity, and abdominal and pelvic traumas.[10,11,13-20] Union rates have not shown to be statistically different between approaches.[11] While outcomes have been favorable, retrograde femoral nailing is not without its own shortcomings. Reported adverse associations include postoperative knee pain, knee arthrosis, and knee septic arthritis.[7,16–18,21,22]

In particular, postoperative knee pain is often cited as an

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adverse outcome of retrograde nailing, with reported rates varying from 20 to 70%.[6,11,12,23,24] In such studies, knee pain is often considered as a binary variable (either present or absent). The quantitative severity of pain, the qualitative nature of pain, and the long-term impact on quality of life have rarely been measured. To our knowledge, few studies report the consequences of knee pain after retrograde femoral nailing in terms of function and patient-reported outcomes, and none utilize the PROMIS scoring system, which is a validated instrument for assessing orthopaedic trauma patients.[25,26] With knee pain rates cited as high as 70%, a better understanding of knee pain and resultant function is essential. This study aims to investigate the incidence and severity of knee pain following retrograde nailing and to better understand consequent functional limitations using validated outcomes tools.

Materials and Methods

This study was approved by the authors' Institutional Review Board (IRB). The institution's patient database was queried using Current Procedural Terminology (CPT) codes to identify 1402 patients who underwent femoral intramedullary nailing between January 2009 and December 2020 at a single Level I trauma center. The accuracy of this query was confirmed through radiographic verification. Inclusion criteria included patients 18 years and older treated with retrograde femoral nails for OTA 32 or 33 fractures.[27] Exclusion criteria included patients younger than 18 years of age, pre-existing osteoarthritis of the knee, documented previous or concomitant articular knee injury, history of previous knee surgery, pathologic fracture, or history of subsequent knee injury at a date after the index procedure. Of the original 1402 patients, 442 patients met all criteria.

Relevant demographic and clinical data were recorded. Following the chart review, a telephone interview was conducted utilizing an IRB-approved telephone script. After obtaining consent, a verbal survey was administered inquiring about knee pain, stiffness, and their subjective perceptions of limb length as well as knee range of motion. Patients then verbally completed the Oxford Knee Score (OKS) and the Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function Short Form 6b. Patients were mailed a review of the study, a copy of the consent form, and contact information for study personnel. Fifty-three patients were ultimately able to be contacted, agreed to participate in the survey, and were included in the final analysis.

Primary outcome variables were OKS and PROMIS assessments. OKS is a 12-item patient-reported survey scored on a scale from 0 (most severe symptoms or worst outcome) to 48 (best outcome), designed to assess function and pain after total knee arthroplasty. Multiple studies have validated the use of OKS in assessing lower extremity orthopedic patient outcomes.[28,29] The minimal clinically important difference (MCID) for OKS in current literature is reported as 5 points.[30] PROMIS is a patient-reported survey developed in conjunction with the National Institute of Health examining the functional effects of pain interference. It is scored numerically, with a higher score representing a *greater* degree of symptomatic dysfunction (opposite to OKS), ranging from a score of 6 (least symptoms) to 30 (most symptoms).[28] To our knowledge, no MCID has been described in the literature for the PROMIS Physical Function Form 6b. However, the extant literature on PROMIS Physical Function Short Forms has shown MCIDs of 2.3-2.5 points for total knee arthroplasty.[31] Secondary outcomes included quality and severity of knee pain, presence of post-traumatic arthritis, and development of complications including infection, nonunion/malunion, and hardware failure.

Statistical analysis included Chi-Square tests for categorical variables, Independent T-Test, One Way Anova for parametric/continuous variables, and Mann Whitney U test for non-parametric data. Multivariate analysis with linear/logistic regression was performed to investigate the relationship of independent variables to knee pain. Means and standard deviations were calculated. P <0.05 defined statistical significance.

Results

Fifty-three patients (40 males, 13 females) above the age of 18 years (mean 36 $\pm$ 14 years) were divided into two sub-groups based on the reported presence (n = 34, Group P for pain) or absence (n = 19, Group NP for no pain) of postoperative knee pain. The average follow-up time after surgery was 62.24 $\pm$ 36.45 months, with no significant difference in follow-up between the two groups. There were no significant differences in baseline demographic data between the two groups [Table 1]. There were no significant differences between the presence of multiple injuries, laterality or mechanism of injury, surgical approach, and OTA classification.

Table 1. Demographics between Group P (Pain) and Group NP (No Pain)

		Pain Group (n=34)	No Pain Group (n=19)	P-value
Gender				
	Male	25 (74%)	15 (79%)	
	Female	9 (26%)	4 (21%)	0.749
Mean age (SD)		36.03 (14.88)	37.95 (15.58)	0.660
Mean BMI (SD)		30.57 (9.36)	28.83 (7.2)	0.485
Tobacco Use				0.158
	Never	12 (35.3%)	11 (57.9%)	
	Current	16 (47.1%)	4 (21.1%)	
	Quit in past	6 (17.6%)	4 (21.1%)	

Table 1. Continued				
Diabetes Mellitus		3 (8.8%)	2 (10.5%)	1.000
Polytrauma		17 (50.0%)	13 (68.4%)	0.194
Laterality				0.516
	Bilateral	1 (2.9%)	0 (0.0%)	
	Left	18 (52.9%)	8 (42.1%)	
	Right	15 (44.1%)	11 (57.9%)	
OTA Classification				0.174
	32	24 (70.6%)	17 (89.5%)	
	33	10 (29.4%)	2 (10.5%)	
Surgical Approach				0.900
	Parapatellar	19 (55.9%)	10 (52.6%)	
	Transpatellar	15 (44.1%)	9 (47.4%)	

Overall complication rates, as well as further sub-analysis of complication types, did not significantly differ between groups [Table 2]. Of note, there was a significant difference in evidence of post-operative radiographic knee arthritis in Group P (n= 7, 20.6%) versus Group NP (n=0, 0.0%) (*P*=0.04) based on the most recently available plain radiographs.

Table 2. Complication Rates

	Pain Group	No Pain Group	P-value
Overall Complication Rate	7 (20.6%)	3 (15.8%)	1.000
Complication Type			
Infection	1 (2.9%)	0	1.000
Hardware Complication	4 (11.8%)	2 (10.5%)	1.000
Malunion/Nonunion	2 (5.9%)	0	0.531
Other	0	1 (5.3%)	0.538

The incidence of pain was present in 64% of patients who underwent retrograde femoral nailing. Of patients reporting pain, 16 (47.1%) reported it as mild [Table 3]. Notably, patients in Group P had a significantly lower OKS (30.38 +/- 10.65, versus 41.95 +/- 6.87; *P* <0.001), representing poorer function. Patients in Group P also scored higher on the PROMIS assessment, representing poorer function, although this difference did not quite reach statistical significance (14.65 +/- 6.76 versus 10.95 +/- 7.09; *P*=0.066). Both the OKS and PROMIS demonstrated a statistically significant correlation with pain severity rating [Table 4, Figures 1 and 2].

Table 3. Pain severity as self-reported by those in the Pain Group

	Number (n=34)
Pain Severity	
Did not qualify	1 (2.9%)
Very Mild	3 (8.9%)
Mild	16 (47.1%)
Moderate	10 (29.4%)
Severe	4 (11.8%)

Table 4. Oxford and PROMIS Score By Severity

		Mean Score	**SD**	**P-value**
Oxford Knee Score	None	47.1	1.3	
	Very Mild	36.7	6.6	
	Mild	37.1	7.0	<0.001
	Moderate	24.7	11.9	
	Severe	21.3	3.3	
PROMIS Score	None	7.9	4.9	
	Very Mild	15.6	8.1	
	Mild	10.8	4.8	0.001
	Moderate	18.5	7.4	
	Severe	18.8	4.9	

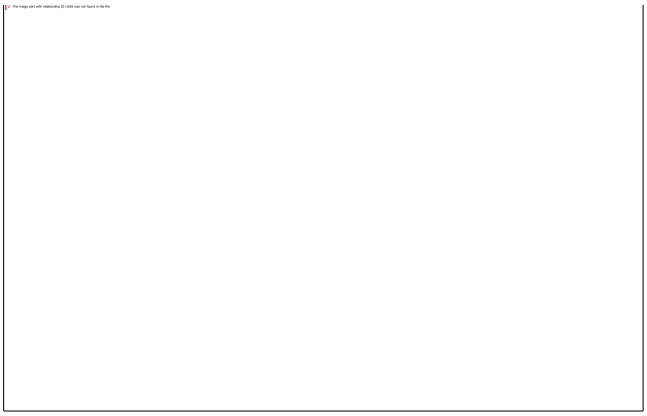

Figure 1. Inverse correlation of OKS and Patient-Reported Pain Severity Rating (score with standard deviation). Patients who reported more severe pain had lower self-reported function as measured by OKS, with lower scores representing more severe symptoms

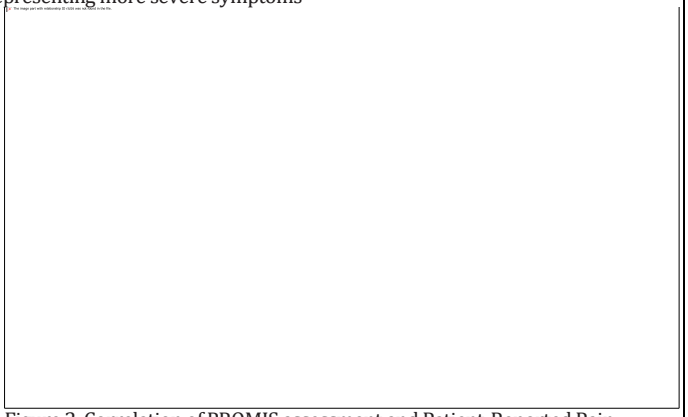

Figure 2. Correlation of PROMIS assessment and Patient-Reported Pain Severity Rating (score with standard deviation). Patients who reported more severe pain had lower self-reported function as measured by PROMIS score. In contrast to OKS, higher scores in PROMISE represent more severe symptoms

OTA fracture sub-group analysis was also performed for Group P patients (n=24 for OTA 32; n=10 for OTA 33) to determine if fracture type affected pain. There were no significant differences between fracture types in frequency (P=0.326) or severity (P=0.326) of pain. There were also no differences in overall mean OKS (OTA 32, 34.83±10.65 versus OTA 33, 30.10±11.07, *P*=0.252) or PROMIS (OTA 32, 12.42± 6.72 versus OTA 33, 15.70 ± 7.66, *P*=0.222) scores between fracture types within the pain group.

Discussion

Knee pain has been described as one of the most common adverse effects of retrograde nailing, with rates reported as high as 70%.[7,11,12,21,22] However, few studies have quantified the severity of pain or examined its functional effects. The purpose of this study was not only to collect data on the incidence of postoperative knee pain but also to utilize validated patient-reported outcome tools to examine the functional effects of pain. Furthermore, we sought to describe the incidence of postoperative complications, including reoperations, nonunion/malunion rate, revision surgeries, and the presence of post-traumatic arthritis related to their symptoms. Altogether, the results of this study aim to help surgeons better counsel patients on postoperative expectations after retrograde femoral nailing.

In this study, 64% of patients endorsed post-operative knee pain, consistent with rates reported in the literature. Further studies would be needed to investigate the etiology of persistent pain, which is currently thought to result from a myriad of factors, including concurrent knee trauma at an initial injury, intraoperative intra-articular damage from surgical technique, or postoperative complications either from the nail placement or post-traumatic inflammation/arthritis.[24,32] In a study of closed femur fractures by Blacksin *et al.*, 97% of patients also had concurrent knee effusions, with nearly 40% of patients demonstrating MCL injuries, 20% with PCL injuries, and nearly 50% of patients with subtle injuries to the extensor mechanism.[32] The aforementioned study also found that 32% of patients with closed femur fractures had bone contusions involving the articular surface.[32] These simultaneous injuries could certainly drive knee pain. Therefore, our study excluded patients who sustained preoperative articular traumatic pathology as evidenced by imaging. Regarding intraoperative technique, there have been cases of articular damage, cruciate ligament disruption, knee sepsis, and patellofemoral damage and degeneration after retrograde nailing.[23] Clement *et al.* examined the intra-articular structures at risk in cadaveric specimens who underwent placement of a retrograde nail. A nail sitting proud in the notch risks injury to the anterior horn of the medial meniscus, tibial insertion of the ACL, and the distal portion of the patellar articular surface.[24] Nail protrusion of 5 mm resulted in patellofemoral impingement and possible damage to the patellar chondral surface with deep flexion.[24] Another variable to consider is paratendinous versus transtendinous approaches to nailing. Some argue that the transtendinous approach is associated with higher rates of chronic knee pain.[33] Their study following patients undergoing intramedullary nailing of the tibia suggested that the dissection of the patellar tendon was responsible for pain.[33] Similar approaches are used in the insertion of retrograde femoral nails, and one could also extrapolate their findings to retrograde femoral nailing. Our study demonstrated no significant difference in pain between either approach.

Our study aimed to quantify the severity of pain experienced by our patients and then evaluate its functional impact on their lives. Of those who reported pain, most endorsed pain once per week (41%), but nearly 59% of patients endorsed pain that occurred constantly or at least once daily. Regarding severity, most patients with pain qualified their pain as minimal/very mild/mild (59%), while the remaining patients qualified their pain as moderate/severe (41%). While many of our patients have very mild or minimal pain, it is important to acknowledge that nearly half endorsing moderate or severe pain may have long-term functional effects, as demonstrated by their inferior patient-reported outcome scores.

Notably, the presence of postoperative radiographic arthritis was also significantly associated with knee pain (*P*=0.041). The rate of postoperative radiographic arthritis was around 7%, which is lower than the rates documented in the current literature.[33] Thomson *et al.* examined the long-

term functional outcomes comparing fixation of distal femur fractures with plate versus intramedullary implant.[34] Over 50% of their patient cohort had significant degenerative changes demonstrated on postoperative radiographs; however, none of these patients required subsequent total knee arthroplasty. There was no significant difference in the rate of osteoarthritis between the IMN and ORIF groups.[34] These data suggest that many factors may predispose patients to knee pain, including subsequent development of radiographic arthritis or co-existing knee pathology missed on the initial patient survey.

Regarding the outcome surveys, there was a significant difference in average OKS and a near-significant difference in PROMIS scores for patients who reported knee pain compared to those who did not. Group P endorsed a significantly lower OKS. Similarly, when comparing the PROMIS score, Group P had higher scores versus Group NP, indicating that their pain had greater interference with their daily activities. Khalil *et al.* investigated the minimal clinically important difference for PROMIS physical health (PROMIS-PH) score in patients with total knee arthroplasty. They found that a difference of 2.3-2.5 points constituted a clinically-relevant difference.[31] This MCID, though calculated for a physical function short form, may not necessarily have been for the Short Form 6b. Furthermore, their study pertained to physical function associated with total knee arthroplasty. [31] This should be considered when extrapolating this value to using Short Form 6b. While nearing statistical significance, we believe that the magnitude of difference in physical function reported between the groups is clinically-relevant and important to recognize in terms of a patient's ability to perform their activities long after healing their fracture.

Using multivariate logistic regression, there was a significant direct correlation between the severity of pain and OKS (P<0.001) as well as PROMIS Scores (P=0.001). Patients who had mild, moderate, or severe pain had lower OKS and higher PROMIS scores. This further validates the OKS and PROMIS scoring systems.

It is important to acknowledge that OTA 32 and 33 fractures occur at different anatomic regions. OTA 33 fractures, in particular, present a challenge given their more distal location and proximity to the articular surface. However, these fractures are still amenable to retrograde nailing, which may offer clinical advantages, including less invasive surgery, improved axial stability, and earlier weight bearing. In our cohort, OTA 33 fractures were treated with retrograde nailing when deemed appropriate by the treating fellowship-trained orthopedic surgeon. One might suppose that these more distal fractures sustained by trauma closer to the knee may represent a confounding factor when isolating the source of knee pain. The Group P sub-analysis broken out by fracture location demonstrated no significant differences in OKS or PROMIS scores as well as reported frequency and severity of pain, indicating that OTA fracture type did not affect reported pain and functional outcomes.

There are several weaknesses to our study. We did not routinely obtain advanced knee imaging to evaluate for intra-articular pathology at the time of index trauma or postoperatively unless indicated. This may have led to under-reporting concurrent knee injury or hardware prominence. Additionally, while all patients had postoperative radiographs to evaluate for the presence of arthritis, not all had radiographs performed when answering the phone questionnaire. It is possible that arthritis had developed and was undiagnosed, which could confound some of our findings. The study's retrospective nature introduces selection bias, and telephone surveys introduce recall bias. Furthermore, it precludes our ability to gather data at multiple time points, particularly in the first postoperative year(s); a prospective study would be better designed to capture additional temporal measurements. Additionally, only 53 patients could be contacted and agreed to participate in the study. Since many eligible patients could not be contacted, our study is liable to sampling bias and may be underpowered to detect subtle differences even though they may exist. Our institution serves an extremely diverse demographic, many of whom contend with severe financial and social barriers that impede access. While only 53 patients met inclusion criteria and completed study follow-up, this is one of the first and largest studies to qualify postoperative knee pain and function in patients treated with retrograde femoral nails. In the future, a prospective trial with a larger patient population investigating these outcome variables in patients with various femoral fixation constructs would overcome many of these limitations.

Conclusion

It is clear that the presence of knee pain had significant functionally-limiting adverse effects on patients' activities. However, the etiology of this pain is likely multifactorial and cannot solely be attributed to retrograde femoral nailing. Further investigation will be required to evaluate the causes of knee pain, including longer postoperative follow-up and more advanced pre- and post-operative imaging to evaluate for concurrent pathology. We found that the development of degenerative joint disease was associated with pain and that the severity of pain incrementally impacts functional outcomes.

Throughout current literature, retrograde femoral nailing is often associated with anterior knee pain. With an incidence rate of 64% and most patients reporting mild to moderate pain severity, this study supports this relationship. While the generation of this pain is somewhat unpredictable and could be confounded by arthritis or concomitant undiagnosed knee injury, it is significantly associated with patient-reported functional outcomes scores. This association should be explained to patients prior to retrograde femoral nailing, so appropriate postoperative expectations can be set.

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