Chapter 8

Long-term functional outcome following intramedullary nailing of femoral shaft fractures

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Abstract

Background: The management of femoral shaft fractures using intramedullary nailing is a popular method. The purpose of this study was to evaluate the long-term functional outcome after antegrade or retrograde intramedullary nailing of traumatic femoral shaft fractures. We further determined predictors of these functional outcome scores.

Methods: In a retrospective study, patients with a femoral shaft fracture but no other injuries to the lower limbs or pelvis were included. 59 Patients met the inclusion criteria. Functional outcome scores (Short Musculoskeletal Functional Assessment (SMFA), Western Ontario and McMaster University Osteoarthritis (WOMAC) index, Harris Hip Score (HHS) and the Lysholm knee function scoring scale) were measured at a mean of 7.8 years (± 3.5 yrs) postoperatively. The visual analog scale (VAS) was used to determine pain complaints of the lower limb.

Results: The ROM of the hip and knee joints was comparable between the injured and uninjured leg, regardless of the nailing technique. Correlation between range of motion and the final outcome scores was found to be fair to moderate. Even years after surgery, 17% of the patients still reported moderate to severe pain. A substantial correlation was observed between VAS and the patient-reported outcome scores. The most significant predictor of functional outcome was pain in the lower limb.

Conclusions: Our findings suggest that the ROM of hip and knee returns to normal over time, despite the used nailing method. However, pain in the lower limb is an important predictor and source of disability after femoral shaft fractures, even though most patients achieved good functional outcome scores.

Introduction

The management of femoral shaft fractures using antegrade or retrograde intramedullary nailing are popular methods. Disadvantages of antegrade nailing of the femur include the risk of injury to the hip abductors or its nerve supply[1], the risk of heterotopic ossification about the hip[2,3], and implant related pain[4]. These complications can be avoided using retrograde nailing. This technique has been advocated in cases of polytrauma; ipsilateral pelvic, acetabular, tibial and femoral neck fractures; bilateral femur fractures; obese and pregnant patients[3-8]. Retrograde nailing involves a transarticular approach and may result in complications of the knee, including infection, damage to the articular cartilage and persistent knee pain[3,4,9].

Multiple studies of both techniques have demonstrated comparable union rates and low rates of infection and malunion[3,4,10-13]. Only a few studies have investigated the functional outcome of patients undergoing intramedullary nailing of femoral shaft fractures. In these reports, the main focus has been postoperative muscle-testing. These studies suggest that musculoskeletal deficits may last for years[14-16].

The purpose of this retrospective cohort study was to evaluate the long-term functional outcome after intramedullary nailing of traumatic femoral shaft fractures by using one generic and three disease-specific patient-reported outcome measures. We further determined predictors of these functional outcome scores.

Materials and methods

In this retrospective study, patients with a traumatic femoral shaft fracture AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) type 32 A-C were included. Between January 1996 and December 2007, 158 patients were treated with antegrade and 95 patients with retrograde intramedullary nailing. All nails were inserted without reaming. The patients were evaluated with clinical and radiological examinations at 6 weeks, and at 3, 6, 9, 12 and 18 months postoperatively. Data from serial clinical and radiographic examinations were reviewed by two authors (MEM and EHV).

We enrolled only adult patients, aged between 18 and 65 years. Additional inclusion criteria were a minimal follow-up of one year, and a healed fracture. Only patients with a femoral shaft fracture but no other injuries to the lower limbs or pelvis were included. Exclusion criteria were a pathologic fracture, bilateral femoral fractures, insufficient follow-up data,

and a history of previous trauma to the lower limbs. This study was approved by our institutional review board, and all included patients gave their informed consent.

Once included and contacted, the patients were invited for a follow-up visit. Parameters that were retrieved included age, sex, mechanism of injury, associated injuries, injury severity score (ISS), side of fracture, AO/OTA type of fracture, location (proximal, middle or distal third) of fracture, degree of soft-tissue injury, in-hospital complications, used nail and method (antegrade or retrograde nailing). Range of motion (ROM) was measured by a goniometer using the neutral-0-method. Angular malalignment was measured radiographically and was defined as > 10 degrees angulation. Rotational malalignment was determined clinically and defined as > 10 degrees malrotation. Axial malunion was present if limb length discrepancy was present of > 2 cm.

We defined non-union as failure of clinical and radiological healing at one year. The clinical criteria to define a healed fracture were absence of pain or tenderness at the fracture site with weight-bearing. Radiographic criteria used to assess healing of the fracture were defined as cortical bridging callus on at least three of the four cortices on the anteroposterior and lateral radiographs.

Patient-based functional outcome assessment was obtained with 4 functional outcome questionnaires. The Short Musculoskeletal Functional Assessment (SMFA) is a validated general functional outcome measure used to assess outcome for a variety of musculoskeletal disorders[17]. The SMFA consists of the dysfunction index, which has thirty-four items for the assessment of patient function, and the bother index, which has twelve items for the assessment of how much patients are bothered by functional problems. The score is a dysfunction measure in which 0 indicates normal function and 100 reflects maximum dysfunction. The Harris Hip Score (HHS) is a disease-specific test used to provide an evaluation system for various hip disabilities and methods of treatment[18]. This observational assessment tool gives a maximum of 100 points and the items include pain (44 points), function (47 points), range of motion (5 points) and deformity (4 points). A total HHS below 70 points is considered a poor result, 70-80 fair, 80-90 good, and 90 to 100 excellent. The (Dutch) Western Ontario and McMaster University Osteoarthritis Index (WOMAC)[19,20] is a disease-specific, self-administered health measure developed to study patients with arthritis of the hip or knee. The index contains the domains of pain, stiffness and physical function. We calculated standardized total scores and subscores for pain,

stiffness and function, all potentially ranging from 0 (worst score) and 100 (best score). Originally designed for assessment of ligament injuries of the knee, the Lysholm knee score[21] has been used for a variety of knee conditions[22,23]. The Lysholm knee score, a disease-specific health measure, evaluates functional disability of the knee using the items instability (25 points), pain (25 points), locking (15 points), swelling (10 points), stair climbing (10 points), squatting (5 points), limp (5 points), and use of support (5 points). The overall score ranges from 0 (worst score) to 100 (best score). The visual analogue score (VAS; 0 – 10 cm) is used to determine pain in the lower limb (0=none, 1-3=mild, 4-6=moderate, 7-10=severe).

Statistical Methods

Categorical variables were summarised as frequencies. Continous data were expressed as mean and standard deviation. Mann-Whitney test was used to evaluate differences wih regard to the functional outcome scores between dichotomous variables. Differences between the injured and uninjured leg were analyzed using Wilcoxon Signed Ranks Test. Spearman's correlation coefficient was used to assess the association of continuous variables (age, ISS, ROM of the hip and knee, and VAS) with the patient-reported functional outcome questionnaires. According to the method of Landis and Koch[24] correlation coefficients of 0 to 0.20 represent slight agreement, 0.21 to 0.40 fair, 0.41 to 0.60 moderate, 0.61 to 0.80 substantial, and greater than 0.80 almost perfect agreement. A two-tailed p-value of < 0.05 was considered significant.

In order to account for possible confounding with other variables, we also performed a multivariable linear regression analysis, using the forward method. The number of explanatory variables that can be included in the multivariable linear regression analysis is limited by the sample size of this study. Instead of entering all potential explanatory variables, we selected only those that were either significant or nearly significant ($p<0.10$) in the bivariate analysis.

Results

Of the 79 patients who met the study criteria, 16 patients could not be contacted, 3 were unwilling to participate, and 1 died during follow-up. Thus, 59 (75%) were available for final evaluation with an average time to follow-up of 7.8 years (Table I).

Table I. Patient and injury characteristics.

	Antegrade group n=40	Retrograde group n=19	p-value
Time to follow-up (months)*	100 (46)	82 (30)	0.073
Male/female	28/12	17/2	0.19
Mean age (years)*	34 (12)	37 (11)	0.26
Side (R/L)	23/17	8/11	0.40
Cause			0.085
- traffic	33	19	
- other	7	0	
Injury severity score*	15 (9.3)	13 (5.3)	0.27
Associated injuries			0.16
- head	16	4	
- spine	2	2	
- thorax	7	7	
- abdomen	5	1	
- upper extremity	12	7	
Open fractures	4	2	1.0
AO/OTA type			0.26
- A	24	8	
- B	14	8	
- C	2	3	

*The values are given as the mean with the standard deviation in parentheses.

The antegrade and retrograde treated patients were comparable with regard to age, sex, mechanism of injury, associated trauma, ISS, side of fracture, number of open fractures, and AO/OTA type of fracture. The incidence of complications did not differ between these patients, and there were no cases of infection. At the time of union, there were no patients with a angular or rotational malalignment of ≥ 10 degrees. An angular deformity between 5 and 10 degrees was seen in 7 patients (5 antegrade and 2 retrograde nails). None of the patients had a limb length discrepancy of > 2 cm.

The ROM of the hip of the injured leg was comparable to the uninjured leg (Table II), regardless the used nailing technique. The mean knee flexion of the affected leg was similar to the unaffected leg (p = 0.21). However, the mean knee flexion in the antegrade group

was 143 degrees and in the retrograde group 132 (p = 0.012). Extension deficit of more than 5 degrees was observed in only one patient (retrograde group).

Table II. Ranges of motion of the hip and knee after femoral nailing*.

		Injured leg	Uninjured leg	p-value
Hip	Flexion	117 (18)	118 (16)	0.88
	Extension	22 (8)	22 (8)	0.61
	Abduction	54 (17)	58 (17)	0.67
	Adduction	28 (7)	30 (6)	0.53
	Internal rotation	23 (7)	25 (6)	0.12
	External rotation	41 (10)	38 (8)	0.051
Knee	Flexion	138 (21)	143 (15)	0.035

* The values are given as the mean with the standard deviation in parentheses.

The scores on the patient-reported outcome measures are presented in Table III. Between the two nailing groups, there were no significant differences in the 4 functional outcome questionnaires: SMFA, HHS, WOMAC, and Lysholm knee score. Furthermore, the mean VAS was comparable between the antegrade and retrograde group. However, moderate to severe pain was reported bij 17% of the patients, whereas 59% had no pain and 24% had mild pain.

Table III. Functional outcome scores*.

		Overall	Antegrade group	Retrograde group	p-value
SMFA		**14 (15)**	**15 (16)**	**12 (12)**	**0.47**
	- Function Index	15 (16)	15 (16)	14 (14)	0.60
	- Bothersome Index	17 (19)	18 (20)	16 (18)	0.71
WOMAC		**90 (17)**	**88 (19)**	**95 (8)**	**0.34**
	- Pain	91 (17)	88 (19)	96 (7)	0.14
	- Stiffness	85 (24)	84 (24)	87 (25)	0.58
	- Function	90 (18)	88 (21)	96 (7)	0.33
Lysholm		**80 (22)**	**79 (24)**	**83 (17)**	**0.70**
HHS		**91 (13)**	**91 (13)**	**92 (12)**	**0.64**
VAS		**1.5 (2.2)**	**1.5 (0.34)**	**1.7 (0.53)**	**0.71**

* The values are given as the mean with the standard deviation in parentheses.

Explanatory variables that had a significant or nearly significant association with the functional outcome scores SMFA, WOMAC, HHS and Lysholm knee score in the bivariate analysis are shown in Table IV.

Table IV. Results of bivariate analysis.

	Rho	p-value
SMFA		
- VAS	0.67	<0.001
- Flexion hip	-0.52	0.001
- ISS	0.37	0.005
- Internal rotation hip	-0.35	0.033
- Flexion knee	-0.34	0.039
- Abduction hip	-0.31	0.061
WOMAC		
- VAS	-0.65	<0.001
- Flexion hip	0.51	0.001
- External rotation hip	0.36	0.025
- Abduction hip	0.33	0.042
- Flexion knee	0.32	0.053
- Internal rotation hip	0.28	0.095
Lysholm		
- VAS	-0.75	<0.001
- Flexion hip	0.47	0.003
- External rotation hip	0.36	0.027
- Flexion knee	0.34	0.038
- Internal rotation hip	0.30	0.063
- ISS	-0.24	0.070
HHS		
- VAS	-0.61	<0.001
- Flexion hip	0.54	<0.001
- Flexion knee	0.51	0.001
- Internal rotation hip	0.39	0.016
- Adduction hip	0.31	0.055
- External rotation hip	0.30	0.067
- Age	-0.28	0.065

Correlations between VAS and the functional outcome questionnaires were substantial with absolute values ranging from 0.61 to 0.75. Correlation was also calculated between the ROM and the functional outcome assessments. The strongest correlation was observed between hip flexion and the functional outcome questionnaires. The average correlationcoefficient was 0.51 (range |0.47 to 0.54|) representing moderate agreement. A weaker correlation was observed between knee flexion and the functional outcome scores. Age and ISS correlated fairly (range |0.24 – 0.37|) with the patient-reported outcome scores.

The multivariable analysis provides information about the degree to which the functional outcome scores are predicted by different variables in the model. The amount of variance in the outcome explained by the independent variables is represented by a statistic called R^2. It is a quantitative measure of how well the independent variables account for the outcome. Pain was the strongest predictor of the patient-reported functional outcome scores SMFA, HHS, and Lysholm knee score. Pain accounted for 38.8% of the variation in SMFA, 36.9% of the variation in HHS, and 55.6% of the variation in the Lysholm knee score. The extent of hip flexion of the affected leg explained 33.6% of the WOMAC, whereas pain only accounted for 8.3% of the WOMAC. Age explained 11.7% of the variance in the HHS, and ISS accounted for 7.7% of the variance in SMFA. The results of the multivariable analysis are summarized in Table V.

Discussion

Intramedullary nailing has become the standard treatment for femoral shaft fractures in the adult population. In general, it is associated with high union rates and low rates of complications[3,4,10-12,10]. Comparative studies[4,10,12,13] showed that there is no difference in the ROM of the knee between antegrade and retrograde femoral nailing. In addition, Herscovici et al[10] and Tornetta & Tiburzi[12] did not find a difference in ROM of the hip as well. We only found a statistically significant difference in knee flexion between antegrade and retrograde nailing. In our opinion this difference is not clinically relevant.

There are conflicting reports with respect to the incidence of knee and thigh pain. Yu et al[13] found that the occurrence of knee pain was similar between the antegrade and retrograde group. Although knee pain was common in the early postoperative period, Tornetta & Tiburzi[12] reported that these complaints subsided by the time of union. Ostrum et al[4] found

Table V. Results of multiple linear regression analysis.

		R^2 change	p-value
SMFA	- VAS	38.8 %	<0.001
	- Abduction hip	10.3 %	0.013
	- ISS	7.7 %	0.021
	- Flexion hip	5.3 %	0.042
WOMAC	- Flexion hip	33.6 %	<0.001
	- VAS	8.3 %	0.034
	- Abduction hip	7.0 %	0.041
Lysholm	- VAS	55.6 %	<0.001
	- Internal rotation hip	6.2 %	0.025
HHS	- VAS	36.9 %	<0.001
	- Age	11.7 %	0.009
	- Adduction hip	6.3 %	0.04

that knee pain was similar in the antegrade and retrograde group, but reported significantly more hip and thigh pain in the antegrade group. Ricci et al[3] found that significantly more patients in the retrograde group reported knee pain, whereas significantly more patients reported hip pain in the antegrade group. Recently, we have reported that complaints of knee pain after retrograde nailing are experienced commonly (23%)[9]. Although the patients in the present study achieved good functional outcome after a mean follow-up of more than 7 years, 17% of these patients still reported moderate to severe pain. Among several variables included in the regression model, pain was found to be the most significant predictor of the general and disease-specific health questionnaires. Age, ISS, and ROM explained to a lesser degree the variance in the patient-reported outcome scores. Pain remains an important source of disability after femoral shaft fractures, even years after surgery. More studies are needed to investigate the exact source of pain after these fractures.

Current literature suggests that residual impairments after intramedullary nailing of femoral shaft fractures include hip abduction weakness, quadriceps weakness, and gait abnormalities[13,14,25-32]. Only a few studies have examined the outcome of patients using validated outcome instruments. Between the early (2.0 months) and late (7.2 months)

assessments after antegrade intramedullary nailing of isolated femoral fractures, Archdeacon et al[32] found a significant improvement in the dysfunction index of the SMFA from 21 to 6.5. This is in accordance with Sanders et al[33]. They reported a significant improvement of the mean SMFA and WOMAC from baseline assessment to the 6-month review. No further improvements in these functional outcome measures have been observed from 6-month to the 12-month measurements.

Helmy et al[34] studied 21 patients with an isolated femoral shaft fracture treated with antegrade reamed intramedullary nailing. At latest follow-up (mean 5.8 years), the SMFA Functional and Bothersome Index were 8 and 9 respectively. This is similar to the Canadian population norms. With a mean follow-up of 100 months for the antegrade group, we found SMFA Functional and Bothersome Index to be 15 and 18 respectively (Table III). This is similar to the retrograde group in our study, indicating that comparable results might be accomplished regardless of the insertion technique used to stabilize the femoral shaft fractures.

Using a femoral nail specially designed for trochanteric insertion, Ricci et al[35] found that hip range of motion was similar to the unaffected side. The mean HHS at the latest follow-up visit (average 15 months) was 77. This is comparable to the present study: the hip range of motion of the affected leg is similar to the uninjured leg, regardless of the utilized nailing technique. The HHS is 79 in the antegrade group and 83 in the retrograde group, indicating good results.

Daglar et al[36] recently evaluated knee function in patients treated with reamed antegrade or retrograde intramedullary nailing of femoral shaft fractures. Using the Lysholm Knee Scores and isokinetic muscle functioning test (mean follow-up of 3.7 years) the results were not different in patients treated with either antegrade or retrograde femoral nailing. After a mean follow-up of 7.3 years, we found no difference in the Lysholm Knee Scores between the antegrade and retrograde group (79 and 83 respectively).

The results of this study should be interpreted with cautious. It has the limitations of a retrospective study. However, we think that the strengths of this study are the length and rate of follow-up. Another limitation is the small sample size. The different measurements used, although not validated to assess treatment of femoral shaft fractures, help us to analyze different aspects of the patients' perspective. There is increasing recognition of the discordance between traditional and patient-based outcomes. To evaluate treatment results

of femoral shaft fractures, more studies using validated functional outcome scores are needed. At present, the cross-cultural adaptation and validation process of the SMFA in Dutch (SMFA-NL) is being conducted.

In conclusion, our findings suggest that the ROM of hip and knee returns to normal over time. However, pain in the lower limb is an important predictor and source of disability after femoral shaft fractures, despite the fact that patients achieved good functional outcome scores. More research is needed to investigate the source of pain after femoral shaft fractures.

Conflict of interest

The authors have no conflict of interest with regard of this manuscript.

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