Original article

Lateral migration with telescoping of a trochanteric fixation nail in the treatment of an intertrochanteric hip fracture

Liu Wanjun, Wang Junqiang, Michael J. Weaver, Mark S. Vrahas and Zhou Dongsheng

Keywords: *trochanteric fixation nail; intertrochanteric hip fracture; fracture fixation; helical blade; complications*

Background The trochanteric fixation nail (TFN) can be used to treat stable and unstable fractures of intertrochanteric hip fractures. We study the common lateral migration that occurs with telescoping of intertrochanteric hip fractures treated with TFN and identify the predictors and relationships to clinical outcomes.

Methods Patient demographic information, fracture type (Arbeitsgemeinschaft für Osteosynthesefragen (AO)/Orthopaedic Trauma Association (OTA) classification), radiographic data, and clinical data were collected. Lateral migration with telescoping was measured. Statistical analyses were performed to determine which variables predicted lateral migration with telescoping. Patient outcome scores were recorded using the Modified Harris Hip Score (MHHS), Hip Outcome Score-Activity of Daily Living (HOS-ADL), and Visual Analog Scale for pain.

Results Two hundred and twenty-three patients (67 males, 156 females) fitted the radiographic and follow-up (average 24.6 months) criteria. The average age was 77.2 years. The average lateral migration with telescoping was 4.8 mm. Twenty-one patients (9.4%) had excessive lateral migration with telescoping (≥10 mm). The quality of calcar reduction (P=0.01) and unstable fracture patterns (P=0.006) were significant predictive factors of lateral migration with telescoping. The mean outcome scores (MHHS and HOS-ADL) were 80.1 points and 78.7 points, respectively. All subjects had no significant relationship to lateral migration with telescoping (P >0.05). Of all the patients who developed lateral migration with telescoping, only one required removal of the blade for hip pain and all patients went on to uneventful union at an average time of 4.5 months.

Conclusions Lateral migration with telescoping is a common mechanical complication of intertrochanteric hip fracture treated with the TFN procedure. It was predicted by the quality of calcar reduction and fracture type. However, this did not affect stable fixation and fracture healing, so rarely leads to clinical problems.

Chin Med J 2014;127 (4):

The use of cephalomedullary devices, such as the proximal femoral nail (PFN), to treat intertrochanteric hip fracture has risen significantly over the last decade.[1] The three most common modes of failure of PFN are varus collapse of the head/neck with cutout, uncontrolled shortening of the neck relative to the shaft, and fractures at the tip of the nail.[2,3]

To overcome failures with cephalomedullary devices, the trochanteric fixation nail (TFN, Synthes, West Chester, PA, USA) with a helical blade device was developed. In biomechanical studies, the TFN has exhibited improved resistance to varus collapse and better rotational control of the femoral head.[4] However, no published data exist with regard to lateral migration with telescoping of the TFN. The purpose of this study was to determine the incidence of lateral migration with telescoping that occurs with intertrochanteric hip fractures treated with the TFN and to ascertain the risk factors that predict lateral migration and their relationship to clinical outcomes.

METHODS

Patients and inclusion criteria

A retrospective review was performed on 341 consecutive patients with the TFN for an intertrochanteric hip fracture at two Level 1 trauma centers between October 2003 and April 2009. Patients were identified by query of our institution's electronic orthopedic trauma database; that is, Ortho Data Utility of Documentation and Education (DUDE). Inclusion criteria included a minimum follow-up of 12 months with a definitive result and existence of immediate postoperative and follow-up high-quality radiographs. Approval was received from our Institutional Review Board.

Surgical techniques

All patients were treated with closed reduction using

DOI: 10.3760/cma.j.issn.0366-6999.20132420

Department of Orthopaedics, Shandong Provincial Hospital, Shandong University, Jinan, Shandong 250021, China (Liu WJ and Zhou DS)

Department of Orthopaedics, Beijing Jishuitan Hospital, Beijing 100035, China (Wang JQ)

Partners Orthopaedics, Massachusetts General Hospital, Harvard School of Medicine, Boston MA 02114, USA (Weaver MJ and Vrahas MS)

Correspondence to: Dr. Mark S. Vrahas, Partners Orthopaedics, Massachusetts General Hospital, Harvard School of Medicine, Boston MA 02114, USA (Tel: 001-617-7262943. Fax: 001-617-7268214. Email: mvrahas@partners.org)

Dr. Liu Wangjun and Dr. Wang Junqiang contributed equally to this work.

traction and manipulation in a supine position on a fracture table. All fractures were reduced as much as possible anatomically. If the fracture reduction was unacceptable, a percutaneous reduction technique was used. Zero, one, or two interlocking screws were employed in the end of the nail. Surgeries were performed in a standardized fashion under image intensification. Standard criteria were not used to decide between a short or long TFN, whether the nail should be locked distally, or determine the number of screws. These decisions were left to surgeon's preference.

Postoperative follow-up

Patients were immobilized on the first postoperative day. Partial or full weight bearing was allowed as decided by the attending surgeon. We emphasized early weight bearing, but the responsible surgeon considered only partial weight bearing when he felt it would be safer (e.g., fracture too unstable, inadequate reduction, or poor screw position in the femoral head). Follow-up was scheduled at 4, 8, and 16 weeks and then 12 months after the operation. If the radiographs that were taken at the 4th week showed maintenance of the screw position and no loss of reduction, patients were allowed to progressively increase weight bearing as tolerated.

Evaluation criteria

Radiographs were analyzed by a single investigator (W.J.L) and confirmed by the senior author (M.S.V). The fracture patterns were classified according to the AO/OTA classification[5] using the preoperative radiographs. Fractures were further classified into stable (31-AI.1, 31-A1.2, 31-A1-3, and 31-A2.1) and unstable fractures (31-A2.2, 31-A2.3, 31-A3.1, 31-A3.2, and 31-A3.3, Table 1).

The immediate postoperative radiographs were used to assess reduction accuracy and position of the blade. The adequacy of calcar reduction was graded on the amount of residual displacement between the neck and shaft as good or poor using Baumgaertner's method.[6-8] A good reduction had normal or slightly valgus neck–shaft alignment on the anteroposterior radiograph, less than 20° angulation on the lateral radiograph, and translation of less than 4 mm on either view. Otherwise, the reduction was graded as poor. The position of the lesser trochanter was evaluated and defined as displaced or non-displaced.

Follow-up radiographs were evaluated to assess fracture healing and lateral migration with telescoping of the blade relative to the shaft of the femur. The amount of lateral migration of the blade was measured by comparing the immediate postoperative radiographs with the most recent radiograph and was calculated as the change in the relative length of the unengaged part of the blade. We defined excessive lateral migration as lateral migration of greater than or equal to 10 mm. The fractures were considered healed when the radiographs clearly demonstrated bone bridging across the fracture.

Table 1. Incidence of different fracture types by AO/OTA classification and stability

AO/OTA classification	Number	Percent	Stability	Percent
31-A1-1	7	3.1	70 stable	31.4
31-A1-2	26	11.7		
31-A1-3	2	0.9		
31-A2-1	35	15.7		
31-A2-2	46	20.6	153 unstable	68.6
31-A2-3	36	16.1		
31-A3-1	18	8.1		
31-A3-2	18	8.1		
31-A3-3	35	15.7		
Total	223	100.0		

Patient outcome scores, including the Modified Harris Hip Score (MHHS), Hip Outcome Score-Activity of Daily Living (HOS-ADL), and Visual Analog Scale for pain, were obtained for all patients at last follow-up.

Statistical analysis

Statistical analysis was performed using SAS version 9.1 (SAS Institute Inc., Cary, NC, USA). Differences were considered to be statistically significant when P <0.05. Student's t-test was used to compare differences between quantitative variables. Logistic regression analysis was used to investigate interactions among the independent variables and their ability to predict the lateral migration of the blade. A relative risk (*RR*) >1 referred to an increasing risk of lateral migration and a *RR* <1 referred to a decreasing risk of lateral migration when it was compared with the reference factor.

RESULTS

Of the 341 consecutive patients identified, 118 patients were excluded for loss to follow-up, with 223 patients remaining for further analysis. Sixty-seven patients were male and 156 were female. The mean age was 77.2 years (range 50–99 years). A long TFN (340–440 mm) was used in 192 (86.1%) patients and a short TFN (170 mm or 235 mm) in 31 (13.9%) patients. Static distal locking was carried out in 114 patients, dynamic distal locking in 24 patients, and both static and dynamic holes were used in 52 patients. Distal locking screws were not used in 33 patients. The mean follow-up was 24.6 months (range 12–76 months). The mean time to fracture healing was 4.5 months (range 3–11 months). The most common mechanism of injury was fall from ground level, which occurred in 207 cases (93%). Seventy-one fractures (31.8%) were considered stable and 152 (68.2%) fractures were considered unstable based on the AO/OTA classification system. The calcar reduction was good in 145 patients and poor in 78 patients. Eighty-eight patients had displacement of a lesser trochanter fragment.

Lateral migration with telescoping of the blade (Figure 1) averaged 4.8 mm (range 3–23 mm) and lateral migration more than or equal to 10 mm was seen in 21 patients (9.4%). The mean outcome scores (MHHS and HOS-ADL) were 80.1 points (range 69–91 points) and 78.7 points (range 66–89 points), respectively. Overall patient satisfaction was 8.1 (of 10).

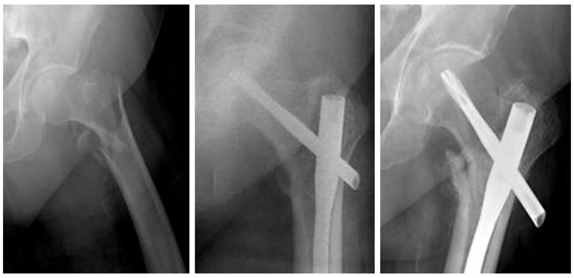

Figure 1. Lateral migration of the blade 22 mm at 3.5 months postoperatively and removal of the blade for hip pain.

Lateral migration with telescoping of the helical blade was not associated with age, sex, nail length, less trochanter displacement, locking screw number, or locking screw type. It was significantly higher in fractures with poor calcar reduction (P=0.01, Student's t-test) and unstable fracture patterns (P=0.006, Student's t-test, Table 2). The logistic regression model showed that the two factors independently predicted an increased risk: calcar reduction (RR=2.585, P=0.047) and fracture stability (RR=8.208, P=0.052, Table 3). MHHS, HOS-ADL, and satisfaction level had no significant relationship to lateral migration with telescoping of the helical blade (P >0.05, Table 4).

Only one case with excessive lateral migration with telescoping had the blade removed to relieve pain from the prominence.

Table 2. Lateral migration with telescoping of blade related to influencing factors

Variables	n	Average lateral migration with telescoping (mm)	$^*P$ values
Sex			0.63
Male	67	4.6	
Female	156	5.1	
Age (years)			0.27
<80	113	6.2	
≥80	110	5.8	
Fracture type			0.006
Stable	70	4.2	
Unstable	153	7.7	
Nail length			0.71
Long	192	4.7	
Short	31	5.2	
Calcar reduction			0.01
Good	145	4.1	
Poor	78	7.6	
Lesser trochanter			0.96
Displacement	88	5.3	
Non-displacement	135	5.4	
Locking screw			0.86
Static distal locking	114	4.6	
Dynamic distal locking	24	5.0	
Both static and dynamic locking	52	4.4	
No distal locking	33	5.3	

$^*P$ value of Student's t-test.

Table 3. Multiple logistic regression analysis of lateral migration with telescoping of blade

Variables	Lateral migration with telescoping of blade		
	RR	95%CI	P values
Sex			
Male versus female	0.871	0.282–2.690	0.811
Age			
Age ≥80 years versus age <80 years	2.307	0.836–6.367	0.107
Fracture type			
Unstable versus stable	8.208	0.982–68.630	0.052
Nail length			
Long versus short	0.93	0.173–5.000	0.933
Calcar reduction			
Good versus poor	2.585	0.922–7.251	0.047
Lesser trochanter			
Non-displacement versus displacement	1.38	0.510–3.734	0.526
Locking screw*			
Dynamic distal locking	0.957	0.110–8.352	0.969
Both static and dynamic locking	0.847	0.140–5.112	0.856
No distal locking	0.703	0.130–3.815	0.683

An RR >1 refers to an increasing risk of lateral migration and an RR <1 refers to a decreasing risk of lateral migration when it was compared with the reference factor. *Reference factor: static distal locking.

DISCUSSION

The TFN with a sliding helical blade was developed to improve fixation of the femoral head and neck. Biomechanical testing of the TFN yielded favorable results, with improved resistance to varus collapse and cutout.[4] Clinical studies indicated that the most common mechanical complication was lateral migration with telescoping of the blade.[9] However, no published data exist with regard to the incidence of lateral migration with telescoping that occurs in intertrochanteric hip fractures treated with the TFN and the risk factors that predict lateral migration and relationships to clinical outcomes.

A study found that stable fractures collapsed along the axis of the dynamic hip screw lag screw about 5.3 mm but unstable fractures slide about 15.7 mm.[10] Another study found that excessive sliding was the major reason for fixation failure and claimed sliding of more than 15 mm to a higher prevalence of failure of the fixation.[11] In addition, an increase in hip pain was also associated with excessive sliding.[12-14] Additionally, in a fairly thin or normal-sized person, if the shaft of the lag screw protrudes beyond the plate in excess of 15 mm, there might be further discomfort.[15]

However, an intramedullary device helps solve some of the fixation stability issues.[16] An intramedullary device provides

Table 4. Lateral migration with telescoping correlated with clinical outcomes

Lateral migration with telescoping (mm)	n	MHHS	HOS-ADL	VAS	Satisfaction level
0–9	202	84.6	83.9	2.9	8.6
≥10	21	79.8	78.7	3.6	7.7
$^*P$ values		0.25	0.43	0.28	0.38

$^*P$ value of Student's t-test. Data are mean values. No significant differences between two groups with regard to clinical outcomes. MHHS: Modified Harris Hip Score, HOS-ADL: Hip Outcome Score-Activity of Daily Living, VAS: Visual Analog Scale.

an early buttress to the medial bone that made contact with the nail itself in the canal, reducing the propensity for excessive lateral migration.[17]

In our study, lateral migration with telescoping of the helical blade averaged only 4.8 mm and excessive lateral migration (≥10 mm) occurred in 21 (9.4%) patients. The TFN procedure used a helical blade in the femoral head instead of a lag screw. The helical blade design did not include removing bone from the femoral head except for the bone removed by the central guidewire. Instead, the blade was designed to be hammered into the femoral head and compress the cancellous bone around it. This not only saved as much of the original bone as possible but created a more dense layer of bone around the implant. The helical design also captured bone in its helical flutes, giving the blade an axial grip in the bone and allowing active intraoperative compression. It can also be seen that the blade occupied a smaller area in the femoral head than a lag screw. The largest advantage of the blade was its cross section with a broad paddle-like footprint, increasing the surface area in the direction resistant to varus loads, reducing stress on the bone, and dramatically increasing its cutout resistance. The four flutes provided rotational control of the femoral head around the implant axis, which was previously impossible to achieve with a lag screw without inserting a second element into the femoral head.

The helical blade of the TFN is designed to slide within the shaft of the nail to allow compression at the fracture site so some lateral migration is expected. There was a significantly increased risk of lateral migration with unstable fracture patterns and in cases in which the calcar reduction was poor.[18] One might expect this as the blade has to slide further in these cases for the fracture to reach stable compression.[19-21]

Gardner et al[22] reported fracture stability was a significant predictor of excessive lateral migration of the helical blade. They found no effect of calcar reduction on lateral migration using the TFN. However, in our study lateral migration of the helical blade was found to be related to both unstable fracture patterns (*P*=0.006) and poor calcar reduction (*P*=0.01).

The MHHS, HOS-ADL, and satisfaction level were not significantly affected by lateral migration with telescoping of the helical blade and only one patient required removal of the helical blade for related symptoms. Our data suggested that lateral migration is not a clinical problem.

There are several limitations to this study. First, although patients were enrolled into our database prospectively, radiographic data were collected retrospectively. Second, patients were treated by a heterogeneous group of surgeons with various backgrounds. While the majority of patients were treated by orthopedic trauma fellowship trained surgeons, many were not. Third, information regarding bone mineral density and body mass index was not available and could confound the results obtained.

In conclusion, the TFN is a reliable implant for the treatment of intertrochanteric hip fractures. The common mechanical complication we observed was lateral migration with telescoping of the helical blade through the nail, and it was associated with calcar reduction and fracture stability. However, this rarely resulted in a clinical problem. Only one patient required a return to the operating room. To reduce the chance of lateral migration of the blade, we recommend that particular attention should be paid to achieving the best anatomic reduction of the fracture as possible.

Acknowledgments: We thank Mr. Hou Tao from the Harvard School of Public Health for expert statistical advice and assistance with statistical programming.

REFERENCES

1. Tyllianakis M, Panagopoulos A, Papadopoulos A, Papasimos S, Mousafiris K. Treatment of extracapsular hip fractures with the proximal femoral nail (PFN): long term results in 45 patients. Acta Orthop Belg 2004; 70: 444-454.
2. Starr AJ, Hay MT, Reinert CM, Borer DS, Christensen KC. Cephalomedullary nails in the treatment of high-energy proximal femur fractures in young patients: a prospective, randomized comparison of trochanteric versus piriformis fossa entry portal. J Orthop Trauma 2006; 20: 240-246.
3. Ruecker AH, Rupprecht M, Gruber M, Gebauer M, Barvencik F, Briem D, et al. The treatment of intertrochanteric fractures: results using an intramedullary nail with integrated cephalocervical screws and linear compression. J Orthop Trauma 2009; 23: 22-30.
4. Sommers MB, Roth C, Hall H, Kam BC, Ehmke LW, Krieg JC, et al. A laboratory model to evaluate cutout resistance of implants for pertrochanteric fracture fixation. J Orthop Trauma 2004; 18: 361-368.
5. Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, et al. Fracture and dislocation classification compendium-2007: Orthopaedic Trauma Association classification, database and outcomes committee. J Orthop Trauma 2007; 21: S1-S133.
6. Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. J Bone Joint Surg Am 1995; 77: 1058-1064.
7. Baumgaertner MR, Solberg BD. Awareness of tip-apex distance reduces failure of fixation of trochanteric fractures of the hip. J Bone Joint Surg Br 1997; 79: 969-971.
8. Erez O, Dougherty PJ. Early complications associated with cephalomedullary nail for intertrochanteric hip fractures. J Trauma Acute Care Surg 2012; 72: E101-E105.
9. Liu W, Zhou D, Liu F, Weaver MJ, Vrahas MS. Mechanical complications of intertrochanteric hip fractures treated with trochanteric femoral nails. J Trauma Acute Care Surg 2013; 75: 304-310.
10. Leung F, Gudushauri P, Yuen G, Lau TW, Fang C, Chow SP. Dynamic hip screw blade fixation for intertrochanteric hip

fractures. J Orthop Surg (Hong Kong) 2012; 20: 302-306.

11. Do JH, Kim YS, Lee SJ, Jo ML, Han SK. Influence of fragment volume on stability of 3-part intertrochanteric fracture of the femur: a biomechanical study. Eur J Orthop Surg Traumatol 2013; 23: 371-377.
12. Chen F, Wang Z, Bhattacharyya T. Convergence of outcomes for hip fracture fixation by nails and plates. Clin Orthop Relat Res 2013; 471: 1349-1355.
13. Ma J, Xing D, Ma X, Xu W, Wang J, Chen Y, et al. The percutaneous compression plate versus the dynamic hip screw for treatment of intertrochanteric hip fractures: a systematic review and meta-analysis of comparative studies.Orthop Traumatol Surg Res 2012; 98: 773-783.
14. Karthik K, Natarajan M. Unstable trochanteric fractures in elderly osteoporotic patients: role of primary hemiarthroplasty. Orthop Surg 2012; 4: 89-93.
15. Haq RU, Dhammi IK. Clinical outcome following treatment of stable and unstable intertrochanteric fractures with dynamic hip screw. Ann Acad Med Singapore 2012; 41: 275-276.
16. Andruszkow H, Frink M, Frömke C, Matityahu A, Zeckey C, Mommsen P, et al. Tip apex distance, hip screw placement, and neck shaft angle as potential risk factors for cut-out failure of hip screws after surgical treatment of intertrochanteric fractures. Int Orthop 2012; 36: 2347-2354.
17. De Bruijn K, den Hartog D, Tuinebreijer W, Roukema G. Reliability of predictors for screw cutout in intertrochanteric hip fractures. J Bone Joint Surg Am 2012; 94: 1266-1272.
18. Grave PW, Tampere T, Byn P, Van Overschelde J, Pattyn C, Verdonk R. Intramedullary fixation of intertrochanteric hip fractures: a comparison of two implant designs. A prospective randomised clinical trial. Acta Orthop Belg 2012; 78: 192-198.
19. Kuzyk PR, Shah S, Zdero R, Olsen M, Waddell JP, Schemitsch EH. A biomechanical comparison of static versus dynamic lag screw modes for cephalomedullary nails used to fix unstable peritrochanteric fractures. J Trauma Acute Care Surg 2012; 72: E65-E70.
20. Strauss E, Frank J, Lee J, Kummer FJ, Tejwani N. Helical blade versus sliding hip screw for treatment of unstable intertrochanteric hip fractures: a biomechanical evaluation. Injury 2006; 37: 984-989.
21. Yao C, Zhang CQ, Jin DX, Chen YF. Early results of reverse less invasive stabilization system plating in treating elderly intertrochanteric fractures: a prospective study compared to proximal femoral nail. Chin Med J 2011; 124: 2150-2157.
22. Gardner MJ, Briggs SM, Kopjar B, Helfet DL, Lorich DG. Radiographic outcomes of intertrochanteric hip fractures treated with the trochanteric fixation nail. Injury 2007; 38: 1189-1196.

(Received September 15, 2013)
Edited by HAO Xiu-yuan