



Original Article

Treatment of irreducible femoral intertrochanteric fractures using a wire-guided device

Kai-Bin Fang, Xiao-Cong Lin, Shao-Jian Shi, Zhang-Sheng Dai*

Department of Orthopedic Surgery, Second Affiliated Hospital of Fujian Medical University, Quanzhou, Fujian Province, China

ARTICLE INFO

Article history:

Received 1 May 2020

Received in revised form

25 September 2020

Accepted 30 November 2020

Available online 12 January 2021

Keywords:

Femoral fractures

Hip fractures

Bone wires

Minimally invasive surgical procedures

ABSTRACT

Purpose: Treatment of irreducible femoral intertrochanteric fractures often requires open reduction. However, the technique unavoidably causes patients to suffer greater trauma. As such, minimally invasive techniques should be employed to reduce the surgical-related trauma on these patients and maintain a stable reduction of the fractures. Herein, a minimally invasive wire introducer was designed and used for the treatment of femoral intertrochanteric fractures. The effectiveness of using a wire-guided device to treat irreducible femoral intertrochanteric fractures was evaluated.

Methods: Between 2013 and 2018, patients with femoral intertrochanteric fractures who were initially treated by intramedullary nail fixation but had difficult reduction using the traction beds were retrospectively reviewed. Decision for an additional surgery was based on the displacement of the fracture. The patients were then divided into two groups: those in the control group received an open reduction surgery while those in the observation group received a closed reduction surgery using a minimally invasive wire introducer to guide the wire that could assist in fracture reduction. The operation time, blood loss, visual analogue scale scores, angulation, reduction, neck-shaft angle, re-displacement, limb length discrepancy, and union time were then recorded and analyzed to determine the efficiency of the wire introducer technique. Categorical variables were analyzed by using Chi-square test, while continuous variables by independent *t*-test and the Mann-Whitney test accordingly.

Results: There were 92 patients included in this study: 61 in the control group and 31 in the observation group. There were no significant differences in baseline demographic factors between the two groups. All surgeries were successful with no deaths within the perioperative period. The average follow-up time for the patients was 23.8 months. However, the observation group had a significantly shorter operation time, lower visual analogue scale score, less intraoperative bleeding, and shorter fracture healing time. There were no significant differences in the angulation, reduction, neck-shaft angle, and limb length discrepancy between the two groups.

Conclusion: The minimally invasive wire guide achieved a similar effect to that of open reduction in the treatment of intertrochanteric fractures with difficult reduction. Moreover, the minimally invasive wire introducer is a good technology that accurately guides the wire during reduction. Indeed, it is an effective technique and achieves good clinical outcomes in restoration of irreducible femoral intertrochanteric fractures.

© 2021 Chinese Medical Association. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Femoral intertrochanteric fractures are common fractures that occur mostly in elderly people. Treating these fractures conservatively often leads to the patients being bedridden for long periods of

time. Prolonged bed rests in turn lead to pressure sores, pneumonia, and deep vein thrombosis that can lead to death. As such, intertrochanteric fractures are commonly referred to as the "last fracture of life".¹ Given the limitations of conservative treatment, surgical treatment of intertrochanteric fractures is the preferred choice. Intramedullary nail fixation is minimally invasive and thus has been widely used in recent years.² Simple fractures can be easily reduced and fixed by doctors. But there are complex fractures

* Corresponding author.

E-mail address: fjmuftkb@foxmail.com (Z.-S. Dai).

Peer review under responsibility of Chinese Medical Association.

that are often difficult to reposition, and thus additional techniques need to be used.

However, it is still difficult for closed reduction of 3%–17% of intertrochanteric fractures using a traction bed.³ These fractures are therefore commonly referred to as irreducible intertrochanteric fractures. Techniques such as warp by Kirschner wire prick, bone hook, and clamp are often used in the reduction of these fractures.^{4–6} Nonetheless, these techniques are limited by several factors. The incision should be enlarged. Moreover, this technology could expose doctors and patients to X-ray radiation. In the same line, stable clinical immobilization is also often difficult to obtain using these techniques. Herein, minimally invasive wire introducer was designed and used for intramedullary nail fixation surgery to reduce the trauma of the patients and maintain a stable reduction of the fractures. The clinical outcomes of this technology were then analyzed to determine its efficacy.

Methods

Study design and patients

Femoral intertrochanteric fracture patients treated by intramedullary nail fixation in the Second Affiliated Hospital of Fujian Medical University between 2013 and 2018 were included in the study. All the patients had been hospitalized because of physical trauma after traffic accidents or falls. The average time between injury and operation was 2 days (range 1–5 days). Patients were initially included in the study when their fractures had closed reduction difficulties using the traction beds. Patients older than 60 years with neither prior history of hip surgery nor significant medical complications nor inflammatory joint disease were included in the study. Patients with open or pathological fractures as well as those with vascular or nerve damage were excluded from the study. Their demographic data was collected prior to the operation.

Surgical procedure

Surgery was performed on a traction bed under spinal anesthesia. Longitudinal traction was applied to the fractured limb using a traction bed. Patients whose closed reductions failed were randomly divided into two groups: observation group and control group. The control group received open reduction with a small incision made at the fracture region. Bone hooks and steel wire were used to aid the reduction. The observation group received the closed reduction operation. The minimally invasive wire introducer (Fig. 1) was used to reduce the fractures in the observation group. The front and lateral skin projection points of the intertrochanteric fracture were located using C-arm X-ray. Two small incisions of about 0.6 mm were made at these two points. A wire introducer (semicircular diameter of 120 mm) was then punctured in from the

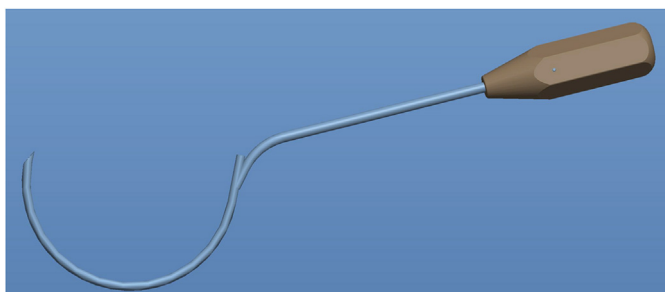


Fig. 1. The wire guide device.

front incision through the medial and the posterior femur fracture and then poked out from the lateral incision under fluoroscopic control. The wire went round the femur fracture using the introducer. A second wire introducer was then punctured in from the lateral incision through the front of the femur fracture and then poked out from the front incision. The two introducers were set to go through the same channel in the muscle and close to the femur surface. The wire went in through the tip of the second wire introducer and then out from the lateral incision guided by the introducer (Fig. 2A and B). The intertrochanteric fracture was reduced when the wire was tightened from the lateral incision under fluoroscopic control. The intramedullary nail was then inserted using percutaneous technique. The head screw was placed in at a tip apex distance (TAD) of less than 25 mm to minimize the risk of cutout in the middle-middle or middle-inferior positions. The standard intramedullary nail was 170–200 mm in length and 9–11 mm in diameter (Fig. 2C).

Postoperative care

Patients underwent a routine blood test one day after surgery to estimate the level of blood loss. They also began quadriceps contraction exercises and ankle pump training under the guidance of a physician. Patients who were able to sit up were also permitted to do so. Subsequent wound cleaning and X-ray examination were done on the second day after surgery. Regular follow-up were then done after 4 weeks, 8 weeks, 12 weeks, 6 months, and 12 months. X-ray examinations were done in each follow-up to check if the fractures were healed. Patients who lacked any sign of fracture healing after 12 weeks were placed on a more frequent follow-up regime of every 3 weeks. Patients were permitted to walk with the aid of crutches but without bearing any weights. Nonetheless, they were permitted to revert back to full activities and weight-bearing after confirmation that their fractures were full healed (Fig. 3).

Evaluation of postoperative pain

The visual analogue scale (VAS) was used to evaluate the postoperative pain of the patients. Two orthopedic physicians independently evaluated the postoperative imaging data of the patients. A chief orthopedic physician conducted the final evaluation in cases where the two physicians reported contrasting results. Maximum cortical displacement and angulation at fracture region on anteroposterior and lateral radiographs were used as indexes to evaluate the reduction. The reduction of fracture was divided into four grades based on the indexes. The fracture was defined as having a good reduction when the angle of the fracture was less than 10° and the maximum displacement distance of the fracture was less than 4 mm. In the same line, the fracture was defined as having acceptable reduction when the fracture was more than 10° or the maximum displacement distance of the fracture was more than 4 mm. However, the fracture was defined as having poor reduction when the fracture was more than 10° and the maximum displacement distance of the fracture was more than 4 mm.⁷ Limb length discrepancy (LLD) was measured by comparing the length of the lower extremities of opposite sides. The LLD was significant when it was more than 1 cm.⁸ The fracture was healed when there was no tenderness in the fracture area or callus formation. This was determined by X-ray examinations. Further to this, the neck-shaft angle was gauged by the postoperative radiograph and compared with that of the opposite side. Reduction was defined as varus reduction when the angle difference between the uninjured hip joint and the operative hip joint was more than 5°. Patient's activity



Fig. 2. (A) A 49 year old male patient with left femoral intertrochanteric fracture; (B) Placing the wire with the assist of the wire guide; (C) Intraoperative fluoroscopy indicated a good position.



Fig. 3. (A) Postoperative X-ray showed that the reduction of fracture was good; (B) Three months after operation, reexamination indicated fracture healing.

and complications were also recorded during follow-up examinations.

Data analysis

Data analysis was done using SPSS V19 software. Continuous data was presented as mean ± standard deviation (SD) or as median and range whereas categorical data was presented as frequencies and percentages. Comparison between categorical variables was performed using the Chi-square test. The independent *t*-test and the Mann-Whitney test were used to compare continuous variables that were normally and non-normally distributed, respectively.

Results

Altogether, 92 patients were included in the study; 31 in the observation group and 61 in the control group. There were no significant differences in baseline demographic factors between the two groups (Table 1). All surgeries were successful with no deaths within the perioperative period. The average follow-up time for the patients was 23.8 months. However, the observation group had a significantly shorter operation time, lower VAS score, less intraoperative bleeding, and shorter fracture healing time. There were no significant differences in the angulation, reduction, neck-shaft angle, and LLD between the two groups. Four patients received revision surgery: one in the observation group and three in the control group. In the same line, only four patients had poor

Table 1
Baseline demographic characteristics of the patients.

Group	Age (year)	Gender (Male/Female)	Fracture classification (AO) A1/A2/A3	Neck-shaft angle of uninjured hip (°)	Time from injury to surgery (day)	Maximum cortical displacement (mm)
Observation	63.53 ± 11.27	12/19	9/15/7	132.73 ± 3.33	1.15 ± 0.72	1.15 ± 0.36
Control	66.72 ± 13.56	33/28	25/29/7	133.16 ± 2.92	1.33 ± 0.66	1.03 ± 0.53
<i>p</i> value	0.26	0.16	0.65	0.53	0.23	0.26

Table 2
Perioperative and postoperative data and results.

Group	Operation time (min)	Blood loss (mL)	VAS scores 1 st day after surgery	Angulation (°)	Reduction (n)		Neck-shaft angle (°)	Union time (week)	Reoperation (n)	Varus reduction >5° (n)	Redisplacement >5 mm at follow-up (n)	Limb length discrepancy >1 cm (n)
					Good	Poor						
Observation	73.53 ± 13.63	135.26 ± 25.33	3.72 ± 0.91	3.16 ± 0.37	26	2	3	133.92 ± 2.96	13.16 ± 3.71	1	3	1
Control	101.26 ± 22.79	223.76 ± 37.55	5.15 ± 1.26	3.23 ± 0.62	50	5	6	134.29 ± 3.53	15.96 ± 3.65	5	3	3
p value	<0.01	<0.01	<0.01	0.57	0.82	0.82	0.62	<0.01	0.71	0.36	0.38	0.71

reduction: one in the observation group and three in the control group. Nonetheless, there were no significant differences in other indexes (Table 2).

Discussion

Reduction is the key factor in determining the operative effect of intertrochanteric fracture of the femur.⁹ Poor reduction is associated with numerous complications such as hip varus, loosening of internal fixation, and refracture.¹⁰ It is more common in irreducible fractures. In 2017, Hélin et al.¹¹ reported that the incidence of fracture dislocation was as high as 45%, and the femoral neck was shortened by nearly 9 mm after reduction when proximal femoral nail antirotation was used to treat unstable intertrochanteric fractures in the elderly people. In 2011, Cho et al.¹² while studying the biomechanics of intertrochanteric fractures reported that the load at the intertrochanteric fracture was related to fracture reduction. Good or poor reduction directly determines the bed rest period of a patient which in turn influences development of complications related to long periods of bed rest.

Traction bed is widely used in reduction of intertrochanteric fractures.¹³ Closed reduction is used to tighten the muscle and soft tissue of the proximal end of the femur through longitudinal traction of the distal end of the fracture. It is also used to achieve the reduction of the fracture end through splint action of the muscle, ligament and joint capsule. There are many muscles with different directions of action attached to the proximal femur. As such, different fractures are accompanied by different injury mechanisms and muscle forces. Cognizant to this, simple longitudinal traction does not always succeed in fracture reduction. Some patients still need open reduction to achieve good fracture reduction. For these patients, it is important to minimize the size of incision and the extent of soft tissue peeling to achieve a good reduction. Maintaining reduction and fixation of fractures using steel wires is a common clinical method because it is simple and results in firm fixation.¹⁴ However, though the fracture can be stably maintained using the wire after open reduction, it results in significant soft tissue damage thereby affecting bone healing.¹⁵

Herein, a minimally invasive wire guide was designed to minimize soft tissue injuries. The device had several advantages. First, the surgery only needed two extra small incisions (about 5 mm) on the skin and deep fascia thereby minimizing injuries to the soft tissues. The device, also enriched the fracture using a wire thereby stabilizing fracture reduction. This allowed proper fixation. Patients who received wire placement using minimally invasive guides had shorter healing time, less intraoperative blood loss, and less pain. These findings were consistent with those of Akhil et al.¹⁶ who reported that the use of minimally invasive methods did not affect the blood supply of femoral tissues. Moreover, the shorter operative time in the observation group confirmed that it was easy to use the device. The procedure achieved the same reduction as an open reduction and with lower incidences of complications and malreduction. Nonetheless, further studies consisting of a larger number of patients and longer follow-up time should be conducted to confirm these results.

Nevertheless, this device is limited by several factors. Its distal end is sharp and thus must be kept close to the bone when moving the instrument around the femur to prevent damaging vessels and nerves around the femur. Generally, a line is drawn from the anterosuperior iliac spine to the lateral margin of the patella. The incision where the wire guide is placed is along this line. It is located using C-arm X-ray thus avoiding injury to vessels

and nerves. Muscles (especially the gluteus medius) should also be protected when using the device.¹⁷

Through our study, we can find that this technique can be used in the treatment of irreducible intertrochanteric fractures. In addition, the technology will not increase the patient's injury when it is used.

Funding

Nil.

Ethical statement

This study was approved by the ethics committee of our hospital. Informed consent was waived by the ethics committee of our hospital.

Disclosure of competing interest

The authors report no conflict of interest related to this manuscript.

References

- Li Y, Zhao WB, Wang DL, et al. Treatment of osteoporotic intertrochanteric fractures by zoledronic acid injection combined with proximal femoral nail anti-rotation. *Chin J Traumatol*. 2016;19:259–263. <https://doi.org/10.1016/j.cjte.2016.07.001>.
- Kokoroghiannis C, Aktseis I, Deligeorgis A, et al. Evolving concepts of stability and intramedullary fixation of intertrochanteric fractures—a review. *Injury*. 2012;43:686–693. <https://doi.org/10.1016/j.injury.2011.05.031>.
- Amini MH, Feldman JJ, Weinlein JC. High complication rate in young patients with high-energy intertrochanteric femoral fractures. *Orthopedics*. 2017;40:e293–e299. <https://doi.org/10.3928/01477447-20161128-04>.
- Parsch K, Weller S, Parsch D. Open reduction and smooth Kirschner wire fixation for unstable slipped capital femoral epiphysis. *J Pediatr Orthop*. 2009;29:1–8. <https://doi.org/10.1097/BPO.0b013e31818f0ea3>.
- Olsson O, Ceder L, Hauggaard A. Femoral shortening in intertrochanteric fractures. A comparison between the Medoff sliding plate and the compression hip screw. *J Bone Joint Surg Br*. 2001;83:572–578. <https://doi.org/10.1302/0301-620x.83b4.11302>.
- Fox KM, Cummings SR, Williams E, et al. Femoral neck and intertrochanteric fractures have different risk factors: a prospective study. *Osteoporos Int*. 2000;11:1018–1023. <https://doi.org/10.1007/s001980070022>.
- Hoskins W, Bingham R, Joseph S, et al. Subtrochanteric fracture: the effect of cerclage wire on fracture reduction and outcome. *Injury*. 2015;46:1992–1995. <https://doi.org/10.1016/j.injury.2015.07.001>.
- Chappell TM, Ebert CC, McCann KM, et al. Distal tibial distraction osteogenesis—an alternative approach to addressing limb length discrepancy with concurrent hindfoot and ankle reconstruction. *J Orthop Surg Res*. 2019;14:244. <https://doi.org/10.1186/s13018-019-1264-0>.
- Parry JA, Barrett I, Schoch B, et al. Does the angle of the nail matter for pertrochanteric fracture reduction? Matching nail angle and native neck-shaft angle. *J Orthop Trauma*. 2018;32:174–177. <https://doi.org/10.1097/BOT.0000000000001096>.
- Sellan M, Bryant D, Tieszer C, et al. Short versus long InterTAN fixation for geriatric intertrochanteric hip fractures: a multicentre head-to-head comparison. *J Orthop Trauma*. 2019;33:169–174. <https://doi.org/10.1097/BOT.0000000000001409>.
- Hélin M, Pelissier A, Boyer P, et al. Does the PFNA™ nail limit impaction in unstable intertrochanteric femoral fracture? A 115 case-control series. *Orthop Traumatol Surg Res*. 2015;101:45–49. <https://doi.org/10.1016/j.otsr.2014.11.009>.
- Cho SH, Lee SH, Cho HL, et al. Additional fixations for sliding hip screws in treating unstable pertrochanteric femoral fractures (AO Type 31-A2): short-term clinical results. *Clin Orthop Surg*. 2011;3:107–113. <https://doi.org/10.4055/cios.2011.3.2.107>.
- Yoon PW, Kwon JE, Yoo JY, et al. Femoral neck fracture after removal of the compression hip screw from healed intertrochanteric fractures. *J Orthop Trauma*. 2013;27:696–701. <https://doi.org/10.1097/BOT.0b013e31829906a0>.
- Gausden EB, Sin D, Levack AE, et al. Gait analysis after intertrochanteric hip fracture: does shortening result in gait impairment? *J Orthop Trauma*. 2018;32:554–558. <https://doi.org/10.1097/BOT.0000000000001283>.
- Klewen C, Morgan J, Redshaw J, et al. Short versus long cephalomedullary nails for the treatment of intertrochanteric hip fractures in patients older than 65 years. *J Orthop Trauma*. 2014;28:391–397. <https://doi.org/10.1097/BOT.0000000000000036>.
- Tawari Akhil A, Kempegowda Harish, Suk Michael, et al. What makes an intertrochanteric fracture unstable in 2015? Does the lateral wall play a role in the decision matrix? *J Orthop Trauma*. 2015;29:S4–S9.
- Arvesen JE, Gill SW, Sinatra PM, et al. Biomechanical contribution of tension-reducing rotator cuff sutures in 3-part proximal humerus fracture. *J Orthop Trauma*. 2016;30:e262–e266. <https://doi.org/10.1097/BOT.00000000000000575>.