MEDICAL SCIENCE MONITOR

DATABASE ANALYSIS

e-ISSN 1643-3750
© Med Sci Monit, 2024; 30: e944383
DOI: 10.12659/MSM.944383

Received: 2024.03.06
Accepted: 2024.05.27
Available online: 2024.06.17
Published: 2024.07.23

Enhanced Outcomes in Femoral Subtrochanteric Fractures Using Long INTERTAN Nails with Titanium Cable Cerclage: A Retrospective Analysis

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABEF 1 **Mingjian Bei**
CF 2 **Yaping Xiao**
BF 3 **Yanfang Xu**
CD 1 **Yimin Chen**
ABG 1 **Qiyong Cao**
AG 1 **Chunpeng Zhao**
AF 1 **Ning Li**
EF 4 **Faming Tian**
AD 1 **Minghui Yang**
AG 1,5 **Xinbao Wu**

1 Department of Orthopedic Surgery, Beijing Ji Shui Tan Hospital Affiliated to Capital Medical University, Beijing, PR China
2 Department of Orthopedic Surgery, Wuhan Third Hospital, Tongren Hospital of Wuhan University, Wuhan, Hubei, PR China
3 Department of Orthopedic Surgery, Second People's Hospital of Changzhi, Changzhi, Shanxi, PR China
4 School of Public Health, North China University of Science and Technology, Tangshan, Hebei, PR China
5 Beijing Research Institute of Traumatology and Orthopaedics, Beijing, PR China

Corresponding Author: Xinbao Wu, e-mail: wuxinbao_jst@126.com
Financial support: This work was supported by the Beijing Scholar Training Program; Beijing Municipal Public Welfare Development and Reform Pilot Project for Medical Research Institutes (JYY2023-11, JYY2023-8); Beijing JST Research Funding (2023OSR-GCZX202205); Beijing Municipal Excellent Plan Empowerment Project (YC202301QX0029); Beijing postdoctoral research Funding (2023--zz--008), and National Key Research and Development (R&D) Plan (No. 2022YFC2504304)
Conflict of interest: None declared

Background: The evidence on use of supplementary titanium cable cerclage (TCC) in treating femoral subtrochanteric fractures (FSF) remains scarce. Therefore, this study aimed to investigate the potential therapeutic effects for FSF patients using TCC.

Material/Methods: A retrospective study of 68 FSF patients treated by a long intramedullary (IM) nailing with (Observation group, n=41) or without (Control group, n=27) TCC was conducted from January 2020 to December 2021. The primary outcome measure was time to postoperative full weight-bearing. Secondary outcome measures were operation time, intraoperative blood loss, number of blood transfusions needed, varus angle loss, excellent and good rate of fracture reduction, Harris score, and survival rate.

Results: Patients were followed up for 13 to 36 months. The excellent and good rate of fracture reduction was 100% in the Observation group versus 92.6% in the Control group (P=0.013), and the varus angle loss and time to postoperative full weight-bearing in the Observation group were significantly less than in the Control group (P<0.05). The intraoperative blood loss in the Observation group was significantly higher than in the Control group (P<0.001). No differences were noted between groups for Harris scores and survival rates at last follow-up.

Conclusions: TCC fixation combined with IM nailing can improve the excellent and good rate of fracture reduction and reduce varus angle loss, as well as shorten the time to full weight-bearing and promote early functional exercise, which offers an effective treatment option for FSF patients who have failed closed reduction.

Keywords: Fracture Fixation, Intramedullary • Hip Fractures • Treatment Outcome

Abbreviations: **FSF** – femoral subtrochanteric fractures; **MO** – mini-open; **IM** – intramedullary; **TCC** – titanium cable cerclage

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/944383

3855 2 3 22

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Introduction

Femoral subtrochanteric fractures (FSF) are a specific type of fracture that occur at the lesser trochanter and extend up to 5 cm distally [1], which can result in hip deformity, dysfunction, limb disability, reduced quality of life, and even death [2]. FSF accounts for about 5% to 34% of proximal femoral fractures [3]. High-energy injuries commonly cause complex FSF in young patients, while low-energy injuries typically lead to FSF in elderly patients due to comorbidities and poor bone quality. FSF is characterized by significant fracture displacement and difficulty in reduction due to the unbalanced muscle tension [4]. The treatment and prognosis of FSF significantly depend on the stress in the femur's subtrochanteric region and the integrity of the medial cortex. Particularly, damage to the medial cortex complicates treatment [5]. Moreover, the femur's subtrochanteric area, situated between cancellous and cortical bone, is highly susceptible to non-union of fracture due to its blood supply.

FSF remain a challenge even for the most experienced orthopedists due to the unique anatomy of the subtrochanteric region, where is characterized by bone hardness and high stress concentration, which contribute to the complexity [6,7]. Additionally, FSF often have large free bone fragments, and the fracture's proximal and distal ends are often significantly displaced by the attached muscles' traction, making closed reduction of FSF challenging. The Seinsheimer classification system has been widely used to characterize the severity and guide the treatment diagnose FSF of the hip since it was first proposed [8]. Briefly, Type I refers to any fracture with less than 2-mm displacement. Type II is divided into 3 subtypes: Type IIa represents a 2-part transverse fracture, Type IIb indicates 2-part spiral with lesser trochanter in proximal fragment, and Type IIc indicates 2-part spiral with lesser trochanter in distal fragment. Type III is a 3-part fracture with 2 subtypes: Type IIIa, characterized by a 3-part spiral fracture with the third fragment in the lesser trochanter, and Type IIIb indicates the third fragment is a butterfly fragment. Type IV refers to 4 or more fragments, characterized by a comminuted fracture affecting both inner and outer skin layers. Type V refers to any fracture with extension into the greater trochanter.

Non-surgical treatment is used primarily for patients who cannot undergo surgery for FSF. However, the extended healing period and complications from prolonged immobility may result in a poor prognosis. Currently, surgical treatment is the primary choice for FSF without relevant contraindication, which offers reliable fracture reduction and fixation, fewer complications, and significantly improves patients' quality of life [4]. However, there is a lack of consensus on a standard treatment plan [9]. Extramedullary and intramedullary fixation are commonly used, depending on the method of fixation [5,10]. The effectiveness of extramedullary fixation treatment is closely linked to the reconstructed medial stability. With the advancement in internal fixation devices and treatment concepts, the integrity of the posterior medial cortex is less important in making surgical decisions than before [4]. Strong internal fixation is beneficial to stabilize fractures and promote fracture healing, and protects the soft-tissue structure [11]. Currently, minimally invasive open reduction together with intramedullary (IM) nail fixation has become an effective option for treatment of FSF when closed reduction fails [9,12]. Particularly, use of a long IM nail theoretically has a biomechanical advantage over a short IM nail. However, IM nailing alone sometimes had difficulties in achieving the necessary stability for fracture fixation, particularly in cases of comminuted fractures with significant displacement [13]. A previous study showed that the mini-open (MO) approach of circumferential cerclage can effectively prevent the displacement and reversal of the broken end of the bone mass, promote IM nail entry, and enhance the stability of the IM nail, which is conducive to fracture healing [13]. Nevertheless, in clinical practice, it also raises concerns, as they can damage the periosteum and its blood supply, devitalize bone fragments, and restrict callus formation during healing [14].

In this study, a clinical retrospective analysis was performed to investigate the potential therapeutic effects for FSF patients who underwent IM nail treatment, with or without TCC fixation, in our hospital from January 2020 to December 2021. The baseline information, radiological results, and social function outcomes of the 2 methods were analyzed to provide a reference for selection of clinical surgical methods and related research.

Material and Methods

Study Design and Setting

This was a retrospective clinical study that included FSF patients who failed closed reduction, who were treated by use of a long INTERTAN IM nail with or without the TCC following MO approach reduction in Beijing Jishuitan Hospital from January 2020 to December 2021. Patients received treatment depending on the surgeon's preference and experience. All patients consented for both procedures prior to surgery, and the study was approved by the Ethics Committee of Beijing Jishuitan Hospital (202004-30), and the study was performed in accordance with the ethics standards of the 1964 Declaration of Helsinki.

Selection Criteria

Inclusion criteria were: (1) The diagnostic criteria for FSF were met; (2) Adults over 18 years of age; (3) long INTERTAN IM nail fixation was used; (4) Closed fracture.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

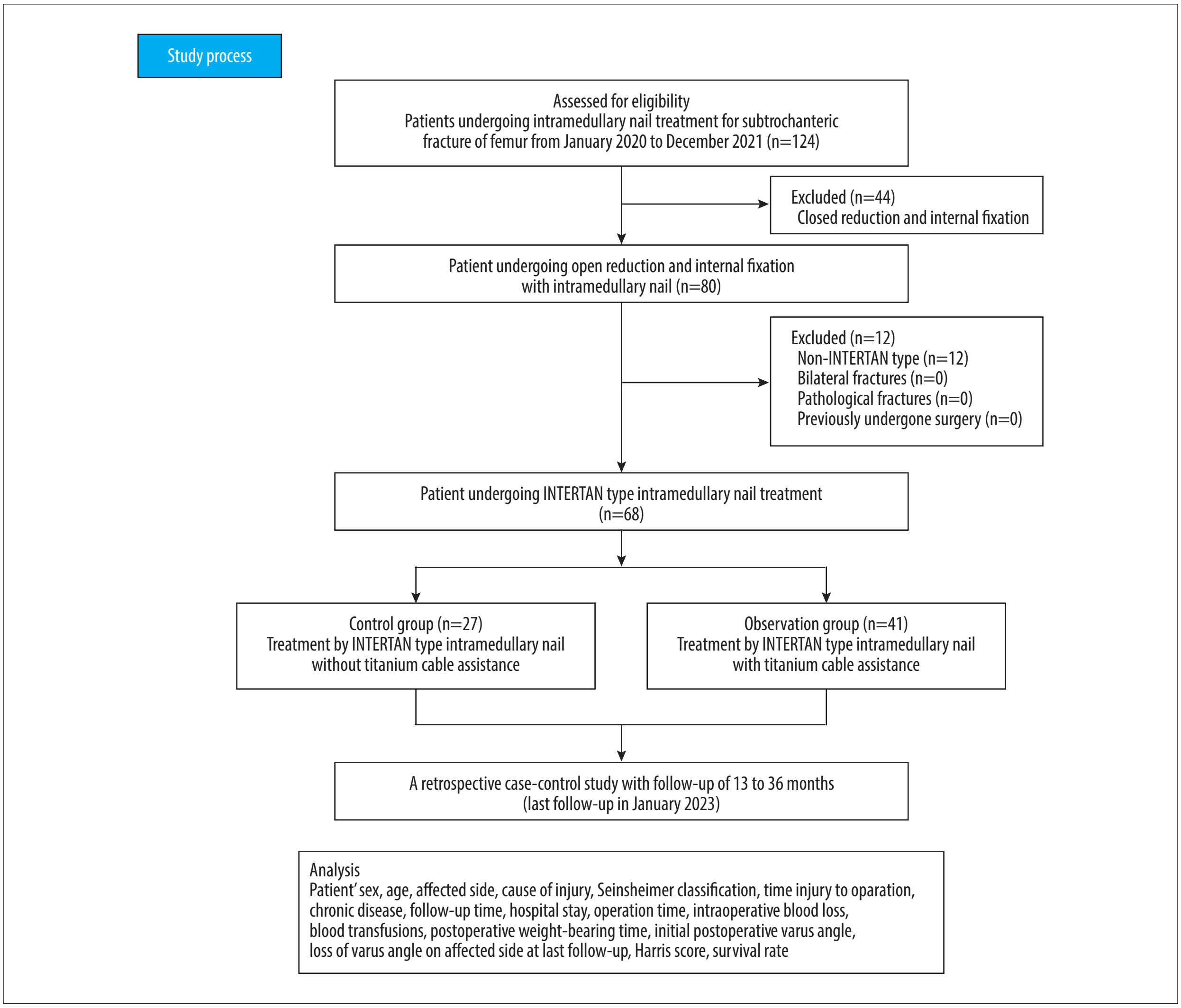

Figure 1. The flow chart of the study.

The exclusion criteria were: (1) Closed reduction; (2) Non-long INTERTAN type nail. (3) Bilateral fractures and pathological fractures; (4) Previously undergone surgery treatment on the ipsilateral femur or hip; (5) open fractures; (6) Combined multiple systems with severe injury or shock.

Population and Data Collection

According to the inclusion and exclusion criteria, 68 cases were included in this study. The study flow chart is shown in **Figure 1**. We screened records of 124 patients with FSF, all of whom had fresh fractures (the interval between injury and surgery is less than 2 weeks). A total of 56 cases were excluded, of which 44 were treated with close reduction and 12 with non-INTERTAN internal fixation materials.

On admission, patients with FSF usually have hip swelling and pain that limits movement, deformity, tenderness, and longitudinal percussion pain. FSF was confirmed by radiographs and CT, and classified according to the Seinsheimer classification system. The Observation group included 41 cases that underwent IM nail treatment combined with TCC, while 27 cases in the Control group did not receive adjuvant treatment with a titanium cable. The last follow-up was conducted in January 2023. We collected data on sex, age, affected side, cause of injury, time from injury to operation, and chronic disease. All patients were given anticoagulation therapy after admission. Preoperative color Doppler flow imaging ruled out deep venous thrombosis of the lower extremities.

Surgical Technique

Observation group: After admission and after contraindications were ruled out, patients promptly underwent surgery under spinal anesthesia. The patient was positioned supine on a traction bed, with a slight elevation of the affected hip.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

In all patients, closed reduction was firstly attempted under G-arm fluoroscopy. The affected limb was reduced on the traction bed by traction, rotation, and abduction. Surgeons assisted in reducing the hip joint by pushing and compressing it when necessary.

If the fracture reduction was unsatisfactory, we sterilized the surgical area and applied sterile sheets. The fracture position was determined using Kirchner wire under G-arm fluoroscopy, then a minimal incision was made on the skin outside the fracture, which could be extended appropriately according to the length of fracture line and the degree of fracture reduction, without fully exposing the fracture ends. Intraoperative reduction was minimally invasive to reduce the detachment of soft tissue and periosteum, which was facilitated using fracture reduction forceps, bone-holder, Hohmann distractors, ball spike pushers, or bone hooks. The choice of using cerclage was based on the quality of the reduction according to the Baumgartner classification [15], which relies on the immediate postoperative X-ray, evaluating displacement and alignment. A good reduction was defined by normal or slight valgus alignment on the AP X-ray, less than 20° of angulation laterally, and a maximum of 4 mm fragment displacement. An acceptable reduction met only 1 or 2 criteria for a good reduction [14].

We always applied the cerclage to aid in the reduction and fixation before insertion of the nail.

After satisfactory reduction under fluoroscopy with the G-arm machine, a longitudinal incision of approximately 2 cm was made 3~4 cm above the greater trochanter tip along the femur's long axis, and then we bluntly separated the subcutaneous fat, fascia, and muscle tissue. All subsequent procedures, including guide needle placement, medullary cavity expansion, and intramedullary needle insertion and fixation, were performed according to standard instructions. The diameter and length of the long INTERTAN nail (Smith & Nephew, Inc., London, UK) were determined based on the expanded medullary cavity condition and pre-surgery measurements. The length of intramedullary needles typically ranged from 300 to 400 mm, increasing in increments of 20 mm. Finally, the incision was sealed layer by layer after extensive saline irrigation.

Control group: The surgical procedure was identical to the Observation group's, but without using TCC for reduction and fixation.

Postoperative Management

Intravenous cephalosporin antibiotics (cefazolin) were administered once to prevent infection, and analgesics were administered orally or intravenously within 24-48 h after surgery. Blood samples were collected to assess for conditions such as anemia, electrolyte disorders, and hypoproteinemia. Anticoagulants (low-molecular-weight heparin or rivaroxaban) were administered 12 h after surgery to prevent deep venous thrombosis in the lower extremities. Patients were encouraged to engage in active and passive exercise training for the hip, knee, and ankle joints without weight-bearing on the first day after surgery, and gait training with partial weight-bearing on the second or third day. Patients started weight-bearing functional training, gradually stopped using crutches, performed non-alternating step-up and step-down training, and gradually began to walk and squat normally at 12~18 weeks. All patients were advised to undergo anterior-posterior and lateral hip joint X-ray examinations at the clinic at 1, 2, 3, and 6 months, and 1 year after surgery.

Data Collection

The collected parameters included hospital stay, operation time, intraoperative blood loss, number of blood transfusions, and time to full postoperative weight-bearing. Additionally, the anteroposterior and lateral hip films were reviewed after surgery to assess fracture reduction and initial varus angle. Finally, the varus angle loss, Harris hip function score, and survival rate were analyzed at the last follow-up. The fracture reduction quality was divided into 3 grades: excellent, good, and poor [16-18]. Briefly, "excellent" was defined as anatomical reduction and an excellent alignment of fracture; "good" was defined as fracture fragment is displaced by less than 1 cm, with an angle less than10°, including a slight internal and external inversion or anterior-posterior angular deformity; and "poor" was defined as the fracture fragment is displaced >1 cm, with an angle greater than10°, including an obvious internal and external inversion or anterior-posterior angular deformity. The varus angle was defined as the difference between the healthy side's femoral neck trunk angle and the initial postoperative angle of the affected side. The varus angle loss was calculated by subtracting the initial postoperative varus angle from the last follow-up varus angle.

Statistical Analysis

IBM SPSS 19.0 software was used for statistical analysis. Measurement data are presented as mean±standard deviation. The homogeneity of variance was tested using the Levene test. The 2 groups of patients were compared by the two-independent samples *t* test. Count data are expressed as absolute numbers and percentages (%) and were compared between the 2 groups using the χ^2 test or Fisher exact test. $P<0.05$ indicated that the difference was statistically significant.

Results

A total of 68 cases were included in this study, including 27 in the Control group and 41 in the Observation group. There were no significant differences between the 2 groups in sex, age, affected side, cause of injury, time from injury to operation, or chronic diseases (all *P*>0.05, **Table 1**). However, the Observation group was dominated by Seinsheimer IIIA, IV and V, while the Control group was dominated by Seinsheimer IIIA and V. There was a significant difference in Seinsheimer types between the 2 groups (*P*=0.007, **Table 1**).

This study had a follow-up period of 13-36 months. There was no significant difference between the 2 groups in length of hospital stay, operation time, or follow-up time (all *P*>0.05, **Table 2**). The intraoperative blood loss in the Observation group was significantly higher than in the Control group (*P*<0.001, **Table 2**). There was no significant difference between the 2 groups in the number of blood transfusions (*P*>0.05, **Table 2**). The postoperative time to full weight-bearing in the Observation group was significantly shorter than that in the Control group (*P*=0.007, **Table 2**). The excellent and good rate of fracture reduction in the Observation group (100%) was significantly higher than that in the Control group (92.6%) (*P*=0.013, **Table 2**). There was no significant difference in the initial varus angle between the 2 groups (*P*>0.05, **Table 2**), but the varus angle loss in the Observation group was significantly lower than in the Control group (*P*<0.001, **Table 2**). There was no significant difference between the 2 groups in Harris hip function score or survival rate (all *P*>0.05, **Table 2**). Typical cases of both groups are shown in **Figures 2 and 3**.

Discussion

In this retrospective study of a cohort of FSF treatment of long IM nail with or without TCC, we found the following: (1) Good reduction is an important prerequisite for the successful placement of IM nails; (2) Cerclage fixation of FSF can significantly improve the quality of reduction and prevent loss of reduction during and after surgery, which is conducive to intraoperative guide needle and IM nail placement; and (3) Cerclage fixation can restore the integrity of the medullary cavity wall (especially the medial wall), as well as increase the overall strength of internal fixation of the fracture, which is conducive to early functional exercise.

Our results showed that the intraoperative blood loss of the Observation group was significantly higher than those of the Control group, indicating that the trauma was more serious in the Observation group, which may be attributed to more intraoperative steps, increased duration of surgery, and greater intraoperative blood loss. Our findings are supported by these of Codesido et al [19], who reported the outcomes for patients with FSF treated using a cephalomedullary nail following open reduction and cerclage wiring versus closed reduction alone. They found that the operation time of the cerclage wiring group was longer, but the hospital stay of the cerclage wiring group was 2 days shorter, and the reduction effect was better. However, Karayiannis et al [14] showed that patients undergoing cerclage cabling had longer length of stay than those that did not. This may be explained by the larger incision, with the potential for increased blood loss and postoperative pain. Although cerclage fixation can increase trauma and intraoperative blood loss, the blood loss is mainly hidden blood loss after the operation. Studies have shown that the degree of fracture instability, comminution, and the gap size after reduction are positively correlated with hidden blood loss [13,18,20]. Therefore, cerclage fixation may improve the stability of the fracture site and reduce blood loss at the fracture site. Moreover, the present results show that the blood transfusion rate and hospitalization time in the Observation group, despite increasing blood loss and duration of surgery, did not increase compared with the Control group. Unfortunately, our study lacked data on indicators for postoperative blood loss. Huang et al [20] found no significant difference in hemoglobin ratio between 2 groups at 1, 3, and 5 days after surgery, showing that, to a certain extent, the additional trauma caused by titanium cable-assisted treatment is still acceptable.

Although the multiple procedures required to pass cables in the Observation group was caused more trauma than in the Control group, there was no obviously adverse impact on radiological results in the present study. The present results show a significantly better rate of excellent and good fracture reduction, as well as markedly less loss of varus angle in the Observation group than in the Control group. Our findings show that TCC can benefit from augmented fixation in FSF. First, cerclage fixation promotes further reduction and maintains the position of the fracture site after initial reduction, and can restore the integrity of the medullary cavity wall, especially the medial wall, which is conducive to placement of the guide needle and subsequent placement of the intramedullary nail. Second, cerclage fixation enhances the overall fixation strength of the fracture. Third, strong fixation helps patients to perform early functional exercise. Our findings are supported by those of Kilinc et al [17], who investigated the effect of the cerclage fixation in the treatment of 52 patients of FSF together with the long PFNA nail fixation, and revealed that it does not negatively impact fracture healing and it can obtain good alignment and stability of the fracture site, and prevent internal fixation failure by producing medial support through anatomical reduction of the fracture.

It should be also noted that patients who underwent TCC had worse trauma, but there was no negative impact on functional

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Table 1. Preoperative general clinical data.

Parameters	Observation group (n=41)	Control group (n=27)	t/χ^2	*p*
Age (years)	75.49±12.57	74.93±14.25	0.17	0.87
Affected side (cases)			0.554	0.457
Left	25	14		
Right	16	13		
Sex (cases)			0.760	0.383
Male	18	9		
Female	23	18		
Cause of injury (cases)			0.927	0.629
Fall	37 (90.2%)	24 (88.9%)		
Fall from height	1 (2.4%)	0 (0%)		
Traffic accident	3 (7.3%)	3 (11.1%)		
Chronic disease (cases)			2.851	0.827
Hypertension	21 (51.2%)	12 (44.4%)		
Digestive system disease	5 (12.2%)	7 (25.9%)		
Diabetes	10 (24.4%)	7 (27.3%)		
Heart disease	8 (19.5%)	3 (11.1%)		
Pulmonary disease	4 (9.8%)	2 (7.4%)		
Cerebral disease	10 (24.4%)	6 (22.2%)		
Coexisting 2 or more diseases	19 (46.3%)	14 (51.9%)		
Seinsheimer type (cases)			17.618	0.007
IIA	1 (2.4%)	4 (14.8%)		
IIB	6 (14.6%)	0 (0%)		
IIC	5 (12.2%)	0 (0%)		
IIIA	13 (31.7%)	16 (59.3%)		
IIIB	0 (0%)	1 (3.7%)		
IV	7 (17.1%)	1 (3.7%)		
V	9 (22.0%)	5 (18.5%)		
Time from injury to surgery (cases)	3.88±3.01	4.96±2.78	-1.60	0.12

outcome, mobility, and mortality in the present study. Inversely, our study showed that titanium cable-assisted treatment of FSF, despite showing no significant difference, can improve postoperative outcomes such as the Harris score and survival rate. Meanwhile, the time to full weight-bearing in the Observation group was significantly earlier than in the Control group, which may be attributed to achieving good alignment and stability of the fractured site, and reducing varus angle loss. Several studies have shown that cerclage cables do have a potential benefit when used to augment fixation in FSF. Huang et al [20] performed a retrospective study of FSF patients who were treated with limited open reduction and PFNA combined with cerclage fixation (observation group) or closed reduction and PFNA fixation (control group). Their results revealed that the operation time of observation group was significantly longer, and the time to first weight-bearing time, hospital stay,

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Table 2. Comparison of observation indicators between the 2 groups.

Parameters	Observation group (n=41)	Control group (n=27)	t/χ^2	*p*
Follow-up time (months)	25.02±6.58	24.14±6.44	0.547	0.586
Hospital stay (days)	5.71±2.96	6.04±2.82	-0.458	0.649
Operation time (mins)	86.22±32.09	73.70±30.59	1.603	0.114
Blood loss (ml)	331.71±164.60	292.59±156.71	3.743	0.000
Blood transfusion (cases)	7 (17.1%)	6 (22.2%)	0.279	0.597
No	34 (82.9%)	21 (77.7%)	-2.780	0.007
Yes	2.46±1.55	3.56±1.64		
Time to full weight-bearing (months)				
Fracture reduction (cases)			8.616	0.013
Excellent	27 (69.9%)	9 (33.3%)		
Good	14 (34.1%)	16 (59.3%)		
Poor	0 (0%)	2 (7.4%)		
Initial varus angle (°)	3.98±2.54	4.08±3.09	0.135	0.893
Varus angle loss (°)	2.35±1.78	6.88±2.86	-7.339	0.000
Harris score	79.17±14.65	74.00±14.63	1.425	0.159
Survival rate (cases)			3.20	0.0736
Surviving	36 (87.80%)	19 (70.37%)		
Death	5 (12.20%)	8 (29.63%)		

and fracture healing time were significantly shorter than in the Control group. The Harris scores of the Observation group were better than those of Control group at 7 days, and at 1, 2, and 3 months after surgery ($P<0.05$). Liu et al [21] also found that the use of cerclage fixation that provides a basis for fracture healing, which is an effective method for treatment of FSF. Similarly, Codesido et al [19] found that the EQ-ED at 12 months and social status at 12 and 18 months in the cerclage wiring group were significantly improved compared to the control group. Moreover, IM nail with wire cerclage is also considered to be an effective method for the treatment of proximal femoral fractures. It facilitates anatomical reduction and stable fixation, thereby shortening healing time and facilitating rapid functional recovery [13]. These findings are in accordance with the results of the present study.

Moreover, the unique displacement direction of the proximal broken end of FSF can easily cause deviation in the entry point, resulting in a loss of fracture reduction or abnormal stress in the subtrochanteric region during intramedullary nail insertion, particularly for long oblique subtrochanteric fractures involving the intertrochanteric Seinsheimer V [22]. The Seinsheimer classification system has been widely used to characterize the severity and guide the treatment and diagnosis of FSF of the hip since it was proposed. Surgical treatment of complex type (III-V) FSF, particular type V, is very challenging due to the difficulty of obtaining and maintaining anatomic reduction and effective fixation. In the present study, both groups mainly consisted of complex type FSF, but there was a significant difference in Seinsheimer types between the 2 groups. Most patients in the Observation group had type III or IV fractures, while the Control group was mainly composed of type IV and V fractures. This potential difference that may account for the variation between the 2 groups, and do not fully illustrate the benefits of TCC technology.

Furthermore, cerclage fixation combined with IM nailing can reconstruct the medial and lateral stability, obtain immediate stability, and meet the needs of patients for early ambulation and promote functional recovery. Cerclage fixation can reduce the gap between the broken ends of the fracture, reduce the incidence of poor fracture union or non-union, and facilitate early fracture healing [21]. In the present study, titanium cable was placed in a minimally invasive manner to

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

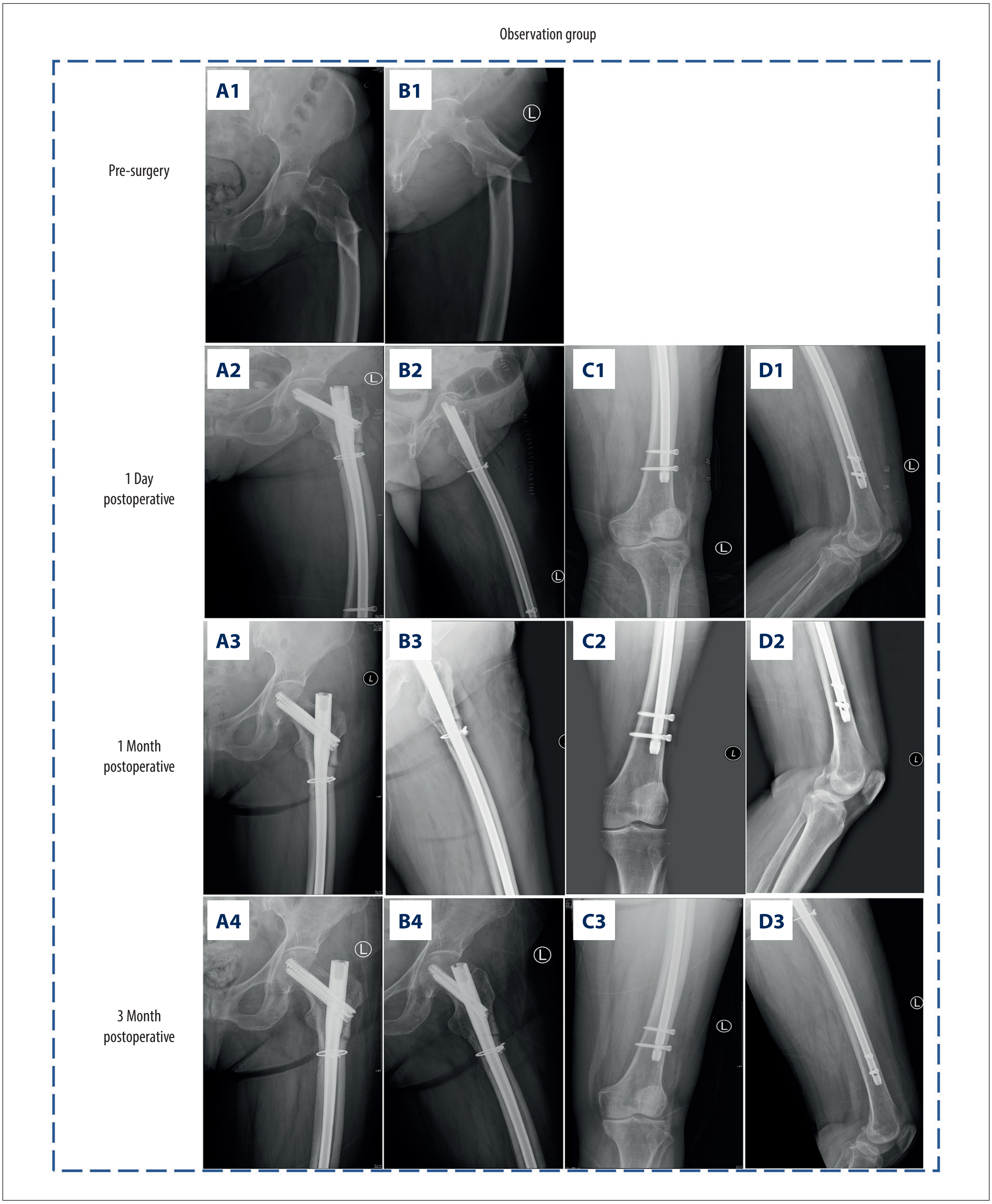

Figure 2. A case of subtrochanteric fracture treated with IM nail combined with titanium cable cerclage fixation. (**A1-A4**) Anteroposterior (AP) radiographs of hip; (**B1-B4**) Lateral radiographs of hip; (**C1-C3**) Anteroposterior (AP) radiographs of distal femur; (**D1-D3**) Lateral radiographs of distal femur.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

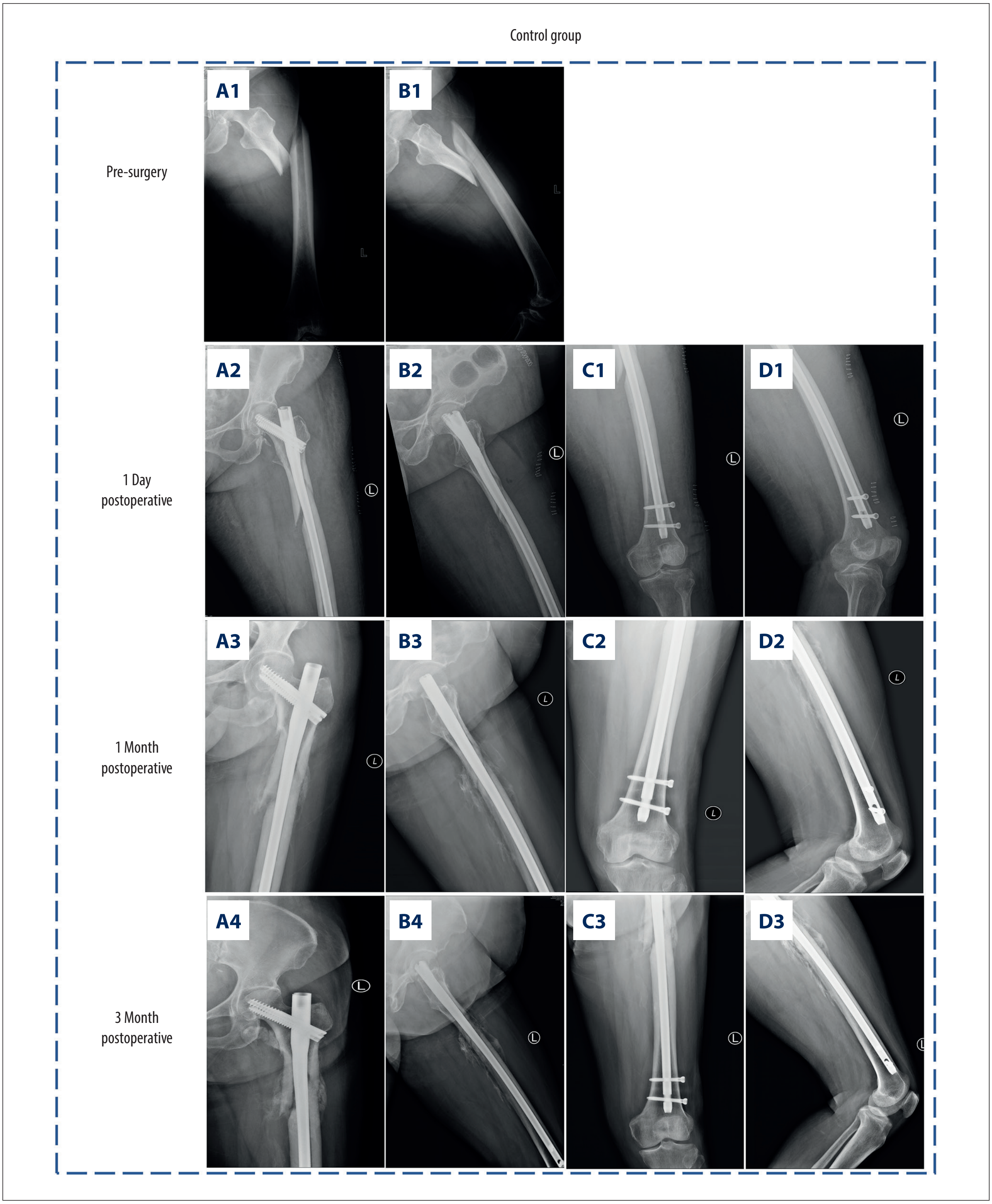

Figure 3. A case of femoral subtrochanteric fracture treated with IM nail without titanium cable cerclage fixation. (**A1-A4**) Anteroposterior (AP) radiographs of hip; (**B1-B4**) Lateral radiographs of hip; (**C1-C3**) Anteroposterior (AP) radiographs of distal femur; (**D1-D3**) Lateral radiographs of distal femur.

protect the blood supply of the fracture site. Periosteal dissection was avoided as much as possible during the operation. The required titanium cable was placed through the guide, assisted with reduction clamp maintenance if necessary. For the patients with comminuted or medial sphenoid bone fragments, the cables can be directly tied and fixed. The fracture reduction can be completed by tightening the cable, reducing the gap of fracture fragments, and achieving stable and effective contact. Our findings are also supported by several studies showing that cerclage of the wire cable can restore the integrity of a proximal fracture end, preventing medial or lateral wall separation and displacement during intramedullary nail insertion, which would lead to further reduction of the fracture [13,16,19].

We believe that the application of cerclage fixation with titanium cables has the following advantages. First, it is conducive to further reduction and maintenance of fracture reduction, so it is easy to establish the correct guide needle tunnel and placement of intramedullary nails. Second, it is beneficial to increase the contact area of cortical bone at the fracture end, thereby promoting fracture healing, shortening healing time, and reducing the incidence of fracture non-union. Thirdly, it is beneficial to improve the strength of internal fixation. The patients can walk earlier, especially elderly patients. Fourth, it is conducive to stress transfer between the bone and the internal fixator and reduces the occurrence of complications.

The limitations of this study are as follows. First, the inherent limitations of retrospective studies cannot be avoided, and randomization was not performed. The investigators and patients were not blinded, and subjective bias may have occurred. Second, the sample size was relatively small, and the data were obtained from a single hospital, so there may have been selection bias. Third, the ratios of hemoglobin at each time point after surgery to preoperative hemoglobin were not measured in the 2 groups; therefore, we could not analyze whether cerclage increased or decreased blood loss after surgery. Additionally, complications such as fracture nonunion and rate of re-operation were not investigated, and the study thus does not fully reflect the benefits of TCC technology. Overall, the results of this study need to be confirmed by large, clinical, randomized, controlled, multicenter studies.

Conclusions

Use of a long IM nail with TCC fixation following an MO approach reduction is an effective treatment option for FSF patients who have failed closed reduction. This method aids in fracture reduction and enhances fixation strength, helps prevent varus deformity, and promotes early functional exercise, thereby improving hip joint function and survival rate.

Acknowledgements

We like to thank the staff of the Department of Radiology and Orthopedics who helped with this research.

Ethics Statement

All patients provided informed consent to both procedures prior to surgery, and the study was approved by the Ethics Committee of Beijing Jishuitan Hospital (202004-30).

Declaration of Figures' Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

References:

1. Seinsheimer F. Subtrochanteric fractures of the femur. J Bone Joint Surg Am. 1978;60(3):300-6
2. Hoskins W, McDonald L, Spelman T, et al. Subtrochanteric femur fractures treated with femoral nail: The effect of cerclage wire augmentation on complications, fracture union, and reduction: A systematic review and meta-analysis of comparative studies. J Orthop Trauma. 2022;36(4):e142-e51
3. Fischer H, Maleitzke T, Eder C, et al. Management of proximal femur fractures in the elderly: Current concepts and treatment options. Eur J Med Res. 2021;26(1):86
4. Ganta A, Kandemir U, Konda SR. Subtrochanteric femur fractures: Pearls and pitfalls. Instr Course Lect. 2023;72:389-403
5. Suzuki N, Kijima H, Tazawa H, et al. Occurrence and clinical outcome of lateral wall fractures in proximal femoral fractures whose fracture line runs from femoral basal neck to subtrochanteric area. Medicine. 2022;101(48):e32155
6. Wang ZH, Li KN, Lan H, et al. A comparative study of intramedullary nail strengthened with auxiliary locking plate or steel wire in the treatment of unstable trochanteric fracture of femur. Orthop Surg. 2020;12(1):108-15
7. Villano M, Innocenti M, Civinini R, et al. The lesser trochanter "Sling fixation technique" in proximal intramedullary nailing of unstable intertrochanteric fractures: A polymer-based cerclage wiring. J Orthop. 2022;34:94-99
8. Guyver PM, McCarthy MJ, Jain NP, et al. Is there any purpose in classifying subtrochanteric fractures? The reproducibility of four classification systems. Eur J Orthop Surg Traumatol. 2014;24(4):513-18
9. An Y, Jiang D. [Biomechanical effects of three internal fixation modes on femoral subtrochanteric spiral fractures in osteoporotic patients by finite element analysis.] Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2023;37(6):688-93 [in Chinese]
10. Basom WC. Use of the extra-long trochanteric plate for severely comminuted fractures of the upper third of the femoral shaft and the subtrochanteric area. J Int Coll Surg. 1956;25(3 Part 1):348-55
11. Yamamoto N, Yamakawa Y, Inokuchi T, et al. Hip fractures following intramedullary nailing fixation for femoral fractures. Injury. 2022;53(3):1190-95
12. Panteli M, Vun JSH, West RM, et al. Subtrochanteric femoral fractures and intramedullary nailing complications: a comparison of two implants. J Orthop Traumat. 2022;23(1):27
13. Kim CH, Yoon YC, Kang KT. The effect of cerclage wiring with intramedullary nail surgery in proximal femoral fracture: A systematic review and meta-analysis. Eur J Trauma Emerg Surg. 2022;48(6):4761-74

14. Karayiannis P, James A. The impact of cerclage cabling on unstable intertrochanteric and subtrochanteric femoral fractures: A retrospective review of 465 patients. Eur J Trauma Emerg Surg. 2020;46(5):969-75
15. Baumgaertner MR, Curtin SL, Lindskog DM, et al. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. J Bone Joint Surg Am. 1996;78(7):1447-48
16. Codesido P, Mejía A, Riego J, et al. Cerclage wiring through a mini-open approach to assist reduction of subtrochanteric fractures treated with cephalomedullary fixation: Surgical technique. J Orthop Trauma. 2017;31(8):e263-e68
17. Kilinc BE, Oc Y, Kara A, et al. The effect of the cerclage wire in the treatment of subtrochanteric femur fracture with the long proximal femoral nail: A review of 52 cases. Int J Surg. 2018;56:250-55
18. Imerci A, Aydogan NH, Tosun K. The effect on outcomes of the application of circumferential cerclage cable following intramedullary nailing in reverse intertrochanteric femoral fractures. Eur J Orthop Surg Traumatol. 2019;29(4):835-42
19. Codesido P, Mejía A, Riego J, et al. Subtrochanteric fractures in elderly people treated with intramedullary fixation: Quality of life and complications following open reduction and cerclage wiring versus closed reduction. Arch Orthop Trauma Surg. 2017;137(8):1077-85
20. Huang C, Gao Y, Gao H, et al. [Effectiveness of proximal femoral nail anti-rotation and cerclage fixation for complicated femoral subtrochanteric fractures.] Zhongguo Xiu Fu Chong Jian Wai Ke Za. 2021;35(8):956-60 [in Chinese]
21. Liu ZD, Xu TM, Dang Y, et al. [Clinical effectiveness of less invasive intramedullary nail fixation combined with titanium cable cerclage for subtrochanteric fractures.] Beijing Da Xue Xue Bao Yi Xue Ban. 2020;52(6):1102-6 [in Chinese]
22. Mohamed Jafarullah Z, Chellamuthu G, Valleri DP, et al. Morphology specific lateral wall reconstruction techniques using cerclage wires in unstable trochanteric fractures. Indian J Orthop. 2020;54(Suppl. 2):328-35

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]