Surgical Selection of Unstable Intertrochanteric Fractures: Proximal Femoral Nail Antirotation Combined With or Without Cerclage Cable

Qing-Chao Huang
Tongji University School of Medicine
Xing Wu (wxdoctor112233@163.com)

Research article

Keywords: Unstable intertrochanteric fractures, Cerclage cable, Proximal femoral nail antirotation

Posted Date: May 27th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-29927/v1

Abstract

Background: Due to the instability of unstable intertrochanteric fractures, the selection of a suitable internal fixation remains challenging for orthopedic surgeons. This study aims to compare the clinical efficacy of proximal femoral nail antirotation (PFNA) combined with a cerclage cable and without a cerclage cable so as to recommend a stable internal fixation method.

Methods: From January 2014 to January 2018, we retrospectively analyzed all unstable intertrochanteric fracture cases who received treatment in the Orthopedics Department of our hospital. One hundred and twenty cases were screened, of which 51 were treated with a cerclage cable, and 69 without a cerclage cable. The follow-up period was one year. Patients were divided into either the PFNA and cerclage cable group (PFNA+cable) or the PFNA only (PFNA) group.

Results: The Harris hip score (HHS), Barthel Index (BI), and Radiographic Union Scale for Hip (RUSH) were evaluated.The fracture healing and weight-bearing time of the PFNA+cable group were shorter than the PFNA group. Regarding the HHS, BI, and RUSH, the PFNA+cable group was higher than the PFNA group at 1, 3, 6, and 12 months after the operation. For the HHS rating, the PFNA+cable group had a higher-excellent rate than the PFNA group, with 96.1% and 84.1%, respectively. All the results mentioned above were statistically significant. The application of a cerclage cable was found to reduce the incidence of complications.It was found that PFNA combined with a cerclage cable improved the stability of fracture reductions, shortened the fracture healing time and postoperative weight-bearing time, significantly improved patients' ability to self-care, and reduced the incidence of postoperative complications.

Conclusions: Therefore, we think PFNA combined with a cerclage cable is a good choice for patients with unstable intertrochanteric fractures.

Background

The most common near-end thighbone fractures are of the thighbone neck, intertrochanteric and subtrochanteric fractures, accounting for approximately 45%, 45%, and 10%, respectively[1]. Among them, intertrochanteric fractures are more common in the elderly, as they often have a poorer physical condition, which is accompanied by osteoporosis, cardiovascular and cerebrovascular diseases, and other comorbidities. Therefore disability and death rates associated with intertrochanteric fractures are high [2]-[4]. Due to developments in science and technology, the increasing number of motor vehicle traffic accidentsthe increasing number of vehicles, and the growing aging population, the incidence of intertrochanteric fractures has rapidly increased. Therefore, the treatment and postoperative functional recovery of intertrochanteric fractures have become increasingly discussed by orthopedic surgeons.

In recent years, with the deepening of orthopedic doctors' understanding of and research on intertrochanteric fractures, a number of intertrochanteric fracture classification systems have been developed according to the anatomical and prognostic characteristics. Of those developed, the most commonly used is the AO Foundation/Orthopaedic Trauma Association (AO/OTA) classification system.

According to the AO classification system, intertrochanteric fractures are subdivided into 31A1, 31A2, and 31A3 [5]. Among them, unstable intertrochanteric fractures include 31A2.2, 31A2.3, 31A3.1, 31A3.2 and 31A3.3. Currently, conservative treatment and surgery are the main treatment strategies for unstable intertrochanteric fractures. Gypsum fixation can result in pulmonary infections, venous thrombosis, malnutrition, bedsores, urinary system infections, joint stiffness, and other complications, so a surgical remedy is considered to be the preferred therapeutic regimen. Proximal femoral nail antirotation (PFNA), dynamic hip screw (DHS), proximal femoral nail (PFN), Intertan, and Gamma are the most common fixation methods for unstable intertrochanteric fractures [6]-[7]. Among them, PFNA has advantages in that only a small incision is required, and it results in less bleeding and firm fixation. However, the PFNA operation is challenging to perform [8]. When a closed reduction is difficult, an open reduction should be performed. However, in order to transfer the patient’s weight through the aligned cataclasis debris and avoid cataclasis displacement during the operation, it is necessary to use various reduction techniques, such as a cerclage cable, to restore the function of the abductor and repair the trochanteric fracture. Although the use of cerclage cables is still controversial, in complex proximal femoral fractures, its potential application value has been advocated [9]. However, regarding the surgical treatment of unstable intertrochanteric fractures, little research has been conducted on the application of cerclage cables. Therefore, this research aims to compare the clinical efficacy of PFNA with or without a cerclage cable and recommend a stable fixation method that can be used for unstable intertrochanteric fractures so as to provide a basis for clinical therapy.

Surgical technique

Following general anesthesia, patients should be placed in a supine position on an orthopedic surgical traction table. Then, traction and fixation of both lower extremities should be conducted, followed by straightening and internal rotation of the affected limbs by 15°, and moderate abduction of the healthy limbs. After a successful closed reduction, the guidewire should be inserted. A hollow drill is then used to enlarge the medullary cavity, and a PFNA intramedullary nail of an appropriate length is inserted. The spiral blade should be placed using the guidewire and guide sleeve. Then, the distal interlocking nail of an appropriate length should be installed. Under the premise of a closed reduction failure, it is important to implement a limited open reduction. With the assistance of X-ray fluoroscopy, bone holding forceps, a periosteal stripper, reduction forceps, and other reduction tools are used for the reduction. After the reduction is satisfactory, a special tool bypass for cable threading is used to bind the cerclage cable near the reduction forceps for fixation.

Methods

Ethical statement

The patients and/or family members were informed of the purpose and nature of this study, and written informed consent was obtained. Our clinical study complies with the provisions of the ethics committee of Shanghai Tenth People's Hospital, School of Medicine, Tongji University, China.

Patients

From January 2014 to January 2018, all patients with unstable intertrochanteric fractures who received treatment in the Department of Orthopedics, Shanghai Tenth People's Hospital, School of Medicine, Tongji University were screened. The final selected cases were all elderly. The inclusion criteria were as follows; aged over 60 years, diagnosed with an unstable intertrochanteric fracture according to the AO/OTA classification system and X-ray examination, and followed-up for one year. One hundred and twenty cases were screened, of which 51 were treated with a cerclage cable, and 69 without a cerclage cable.

Grouping and treatment

Patients were divided into the PFNA only (PFNA) group and PFNA combined with a cerclage cable (PFNA+cable) group. All patients were examined thoroughly before the operation and were given anti-infection, detumescence, pain relief, and other symptomatic treatment. Patients in the PFNA group underwent a standard PFNA operation, while patients in the PFNA+cable group underwent a PFNA operation combined with a cerclage cable. After the operation, we sought to prevent complications such as pulmonary infections, venous thrombosis, bedsores, urinary system infections, and osteoporosis. Patients were encouraged to complete rehabilitation exercises to prevent joint stiffness and promote bone reconstruction.

Follow-up and observation indexes

Postoperative observation indexes included the operation time, intraoperative blood loss, weight-bearing time, and fracture healing time. The function of the articulatio coxae was evaluated using the Harris hip score (HHS) [10]. Activities of daily living (ADL) were evaluated using the Barthel Index (BI) [12]. In intertrochanteric fractures, the Radiographic Union Scale for Hip (RUSH) was used for the iconography evaluation of fracture healing [11]. HHS and BI were initially evaluated preoperatively. Then, HHS, BI, and RUSH were evaluated at 1, 3, 6, and 12 months after the operation.

Statistical analysis

SPSS version 21.0 was used for the statistical analyses. Data are expressed as a mean ± standard deviation. The t-test was used to compare the measurement data, and the Chi-square test was used to compare the enumeration data. For $p<0.05$ was considered statistically significant.

Results

All patients were fixed with PFNA (Synthes®, Oberdorf, Switzerland). All patients were followed-up for one year. The baseline information and follow-up data of all patients were recorded. In this study, 120 patients with unstable intertrochanteric fractures were divided into two groups. Fifty-one cases underwent PFNA with a cerclage cable, and 69 cases underwent PFNA without a cerclage cable. The age distribution of the two groups was not significantly different (p=0.306). The mean age of the patients in the PFNA+cable and PFNA groups was 83.0±10.6 years, and 84.7±7.5 years, respectively. The body mass index (BMI) (p=0.139) and sex (p=0.941) of the two groups were also not significantly different. In terms of hypertension (p=0.28), diabetes (p=0.822), heart disease (p=0.243), and other diseases (p=0.119), the difference between the two groups was minimal. Little differences were found between the two groups regarding the ASA grading and AO classification, with the statistical results being ASA II (p=0.356), ASA III (p=0.28), ASA IV (p=0.879); 31A2.2 (p=0.86), 31A2.3 (p=0.211), 31A3.1 (p=0.867), 31A3.2 (p=0.133), 31A3.3 (p=0.82) (see **Table 1**). The difference in intraoperative blood loss (p=0.214) and operation time (p=0.064) between the two groups was small. The mean weight-bearing time and mean fracture healing time of the PFNA+cable group were 2.94±0.27 months and 3.36±0.23 months, respectively, while those of the PFNA group were 3.73±0.71 months and 4.34±0.22 months, respectively. The weight-bearing time (p=0.000) and fracture healing time (p=0.000) of the PFNA+cable group were significantly shorter than that of the PFNA group. The mean HHS in the PFNA+cable group were 59.9±7.3, 76.7±2.2, 86.2±1.1, 88.2±0.8 and 96.4±2.9 preoperatively, and 1 month, 3 months, 6 months and 12 months after the operation, while in the PFNA group were 60.7±5.2, 75.9±2.8, 82.3±1.6, 83.5±1.2 and 93.1±3.2, respectively. Following a statistical analysis, there was no statistical significance in the HHS preoperatively (p=0.485) and 1 month after the operation (p=0.075). However, the HHS was statistically significant 3 months (p=0.000), 6 months (p=0.000) and 12 months (p=0.000) after the operation. The analysis showed that the PFNA+cable group had superior outcomes to the PFNA group in terms of the recovery of hip joint function from 3 months to 12 months after the operation. In other words, cerclage cables can help to maintain the fracture reduction and improve stability. The mean BI scores in the PFNA+cable group were 49.7±5.3, 54.2±4.4, 83.8±2.1, 89.9±0.7 and 95.0±0.0 preoperatively, 1 month, 3 months, 6 months and 12 months after the operation, while in the PFNA group were 48.9±5.2, 53.3±3.7, 78.6±2.6, 84.6±3.1 and 89.1±2.5, respectively. Regarding the comparison of patients' ADL, there was no statistical significance in BI preoperatively (p=0.410) and 1 month after the operation (p=0.227). However, BI was statistically significant 3 months (p=0.000), 6 months (p=0.000) and 12 months (p=0.000) after the operation. From this, we can see that the ADL of the PFNA+cable group was better than the PFNA group from 3 to 12 months after the operation. Therefore, the use of cerclage cables can improve patients' ADL. The mean RUSH scores in the PFNA+cable group were 18.2±0.8, 25.7±0.6, 27.2±0.9, and 28.5±0.8 at 1, 3, 6, and 12 months after the operation respectively, while in the PFNA group were 14.8±0.7, 23.0±1.1, 25.1±0.8, and 26.5±0.6, respectively. In terms of the imaging score, it was found that the mean RUSH scores of the two groups were statistically significant 1 month (p=0.000), 3 months (p=0.000), 6 months (p=0.000) and 12 months (p=0.000) after the operation. These results show that the PFNA+cable group displayed better fracture healing than the PFNA group (see **Table 2**). We compared the HHS rating between the two groups. The proportion of excellent ratings in the PFNA+cable group was 96.1%, while the proportion of excellent ratings in the PFNA group was 84.1%. This was not significantly different between the two groups (p=0.036). Therefore, the PFNA+cable group appeared to have superior postoperative hip joint function recovery to the PFNA group (see **Table 4**). Through the HHS trend chart, we can see that the HHS of the two groups increased over time. However, the PFNA+cable group had higher HHS than the PFNA group. The HHS growth trend of both groups was flat from 3 to 6 months after the operation, but the HHS of the two groups gradually increased from 6 to 12 months after the operation. While the hip joint function of both groups improved over time, the recovery rate of the PFNA+cable group was faster than the PFNA group. The hip joint function of the two groups was close to normal from 3 to 6 months after the operation. Functional recovery of the articulatio coxae was slow, and the hip joint function continued to return to normal from 6 to 12 months after the operation (see **Figure 3A**). The BI scores of the two groups were seen to increase over time. However, the BI scores of the PFNA+cable group increased faster than the PFNA group. The growth rate of the BI scores of both groups was the fastest from 1 to 3 months after the operation and then slowed down after 3 to 6 months. Therefore, it can be inferred that the PFNA+cable group had better ADL than the PFNA group. Patients in both groups had the fastest improvement in ADL from 1 to 3 months after the operation, and then gradually returned to normal ADL after 3 to 12 months (see **Figure 3B**). In terms of the RUSH score, the fracture healed continuously over time. The fracture healing rate was the fastest 1 to 3 months after the operation. Then, the fracture healing rate slowed down until it was fully healed. It can be seen from **Figure 3C** that the mean RUSH score of the PFNA+cable group was higher than the PFNA group. Therefore, we speculate that the PFNA+cable group healed faster. No patient died during the follow-up period. However, a number of postoperative complications occurred. Two cases of superficial wound infections occurred in the PFNA group, along with one in the PFNA+cable group. All patients received symptomatic treatment with antibiotics, and the wounds healed well. Three patients developed a deep infection in the PFNA group, along with two in the PFNA+cable group. All patients received debridement and antibiotic treatment, of which two patients in the PFNA group needed ventricular septal defect (VSD) treatment to promote wound healing, while only one patient in the PFNA+cable group needed VSD treatment. The wounds of all these patients healed well. In the PFNA group, one case had a fracture nonunion, two cases had screw penetration, and one case had a screw cut-out. All of these underwent secondary surgery. These complications did not occur in the PFNA+cable group (see **Table 3**). In comparing **Figure 1** with **Figure 2**, we can see that the fractures of the PFNA+cable group had partially healed by one month after the operation, but the fractures of the patients fixed with PFNA only had not started to heal. At 12 months after the operation, the PFNA+cable group fractures had all healed, while there was one fracture nonunion in the PFNA group. A total hip replacement was used to treat the fracture nonunion.

Table 1
Comparison of basic data between the two groups.

Characteristics	**PFNA+cable (n = 51)**		**PFNA (n = 69)**	**t/c^2**	**p value**
Age (years)		83.0±10.6	84.7±7.5	1.029	0.306
BMI(kg/m^2)		22.14±2.52	22.93±3.10	1.491	0.139
Gender	Men	13	18	5.451	0.941
	Women	38	51		
Preoperative diseases					
	Hypertension	23	38	1.167	0.280
	Diabetes	15	19	5.080	0.822
	Heart disease	12	23	1.364	0.243
	Others	15	12	2.430	0.119
ASA grading					
	II	23	37	0.853	0.356
	III	28	31	1.167	0.280
	IV	0	1	2.321	0.879
AO classification	31A2.2	23	30	3.120	0.860
	31A2.3	13	25	1.564	0.211
	31A3.1	4	6	2.790	0.867
	31A3.2	7	3	2.560	0.133
	31A3.3	4	5	5.192	0.820

Table 2
Surgical factors and follow-up results between PFNA+cable group and PFNA group.

Characteristics		PFNA+cable (n = 51)	PFNA (n= 69)	t	p value
Operation time(mins)		77.4±10.6	73.5±11.8	1.868	0.064
Intraoperative blood loss(ml)		191.4±15.7	194.7±13.2	1.249	0.214
Post-operative weight-bearing time (months)		2.94±0.27	3.73±0.71	7.546	0.000
Fracture healing time (months)		3.36±0.23	4.34±0.22	23.66	0.000
RUSH score	One month after operation	18.2±0.8	14.8±0.7	24.75	0.000
	Three months after operation	25.7±0.6	23.0±1.1	15.86	0.000
	Six months after operation	27.2±0.9	25.1±0.8	13.47	0.000
	Twelve months after operation	28.5±0.8	26.5±0.6	15.65	0.000
HHS	Preoperative	59.9±7.3	60.7±5.2	0.701	0.485
	One month after operation	76.7±2.2	75.9±2.8	1.812	0.075
	Three months after operation	86.2±1.1	82.3±1.6	14.98	0.000
	Six months after operation	88.2±0.8	83.5±1.2	24.26	0.000
	Twelve months after operation	96.4±2.9	93.1±3.2	5.809	0.000
BI score	Preoperative	49.7±5.3	48.9±5.2	0.826	0.410
	One month after operation	54.2±4.4	53.3±3.7	1.215	0.227
	Three months after operation	83.8±2.1	78.6±2.6	11.73	0.000
	Six months after operation	89.9±0.7	84.6±3.1	11.97	0.000
	Twelve months after operation	95.0±0.0	89.1±2.5	16.83	0.000

Table 3
Postoperative complications between PFNA+cable group and PFNA group.

Complications	PFNA	PFNA+cable
Superficial infection	2	1
Deep infection	3	2
VSD requirement	2	1
Nonunion	1	none
Screw penetration	2	none
Need for revision surgery	4	none
Screw cut-out	1	none

Table 4
HHS rating between PFNA+cable group and PFNA group at twelve months after operation

Characteristics	PFNA+cable (n = 51)	PFNA (n = 69)	c^2	p value
HHS rating			4.386	0.036
	80-89 Good 2	11		
	90-100 Excellent 49	58		

Discussion

We found that patients without a cerclage cable were prone to fracture displacement during the follow-up period, while patients with a cerclage cable were not. Therefore, we believe that cerclage cables can keep the fracture in a good anatomical reduction or close to anatomical reduction. The displacement of fracture fragments or bone splitting in the process of nail placement can be avoided by using a cerclage cable, which helps to stabilize the aligned fracture fragments. Additionally, most of the patient’s body weight can be transferred through the aligned bone fragments so that the whole fixation is more stable.

Due to the instability of unstable intertrochanteric fractures, it is important to select an appropriate internal fixation, which can achieve and maintain stable anatomical reduction until the fracture heals. This will help to shorten the time to weight-bearing and reduce the incidence of postoperative complications. During the surgical procedure, when a closed reduction cannot be successful, we recommend an open reduction combined with a cerclage cable to achieve a more stable fracture reduction effect. Afsari, A et al. believe that the proper use of cerclage cables for clamp-assisted reduction and intramedullary nail fixations can achieve a good reduction effect and high fracture healing rate [13]. Kulkarni, S. G. et al. proposed that cerclage cables can improve the fixation strength of the intramedullary nail and help to reduce the incidence of surgical complications [14]. Apivatthakakul, T. et al. asserted that cerclage cables could help reduce and maintain refractory intertrochanteric fractures [15]. Kilinc, B. E. et al. proposed that open reductions combined with cerclage cables do not adversely impact fracture healing [16]. It has been reported that the efficacy of using minimally invasive cerclage cables to subtrochanteric fractures is similar to that of reverse intertrochanteric fractures [13]. Compared to reductions without cerclage cables, the reoperation rate and reduction quality are improved, and the fracture displacement is reduced when cerclage cables are used [17]-[18]. To obtain the correct nail insertion point so as to achieve an anatomical reduction or close to anatomical reduction, some patients must undergo an open reduction. Due to the abductor muscle, this can easily lead to distal and proximal fracture displacements [19]-[20]. Due to unsuccessful closed reductions, we suggest using cerclage cables after an open reduction, because the use of a cerclage cable can maintain the initial stability of the fracture site and reduce the abduction of the proximal fracture. In early weight-bearing, the cerclage cable can help to stabilize the aligned bone fragments so that the patient's weight is transferred through the aligned bone fragments. This helps to maintain the fracture reduction and reduces the incidence of postoperative complications. We found that the PFNA+cable group had a shorter weight-bearing time than the PFNA group, which was predominately due to the stable reduction of the fracture fragments provided by the cerclage cable. According to a biomechanical report, cerclage cables not only improve the likelihood of successful bone synthesis in complex fractures but also provide important posterior medial support for unstable intertrochanteric fractures [21]. For young patients, when the closed reduction of intertrochanteric fractures is challenging, using a steel cable can be a good solution. It is easy to drill and place nails, reduces the occurrence of intraoperative complications, and helps to protect the fracture reduction [22]. It has been alleged that the use of cerclage cables destroys the blood vessels at the fracture site and the blood supply for fractures, which leads to nonunion [23]. However, a study using an animal model without a fracture found that the use of cerclage cables could protect the supportive blood vessels at the fracture site [24]. After follow-up, it was found that all the patients who had been treated with cerclage cables were completely healed. Therefore, we believe that the cerclage cables had no harmful effects on fracture healing. Some scholars believe that the normal fracture healing time will not be affected by the use of steel cables [25]. Intramedullary nail is the preferred treatment for subtrochanteric fractures, especially unstable intertrochanteric fractures [26]-[32]. PFNA has been shown to slow rotation and medial cortical collapse mainly because the spiral blade can compress the cancellous bone and increase its stability. Biomechanical tests have also shown that in osteoporotic bone, the cut-out rate of PFNA spiral blades is lower than the more commonly used screw systems [33]-[34]. Therefore, we use PFNA to treat patients with unstable intertrochanteric fractures. Cerclage cables can keep a fracture reduction longer [35]. It has been suggested that a larger incision is required when cerclage cables are used, which causes greater damage to the soft tissue and periosteal circulation [36]. Some studies have suggested that the periosteum is dissected along with multiple musculo-periosteal vessels, and the direction of these vessels is circumferential as opposed to longitudinal [37]. Other studies have shown that the periosteal circulation damage caused by cerclage cables is negligible in oblique or spiral intertrochanteric fractures [38]. In biomechanics, intramedullary fixation has more obvious advantages than extramedullary fixation [39]. Many clinical studies have proposed that intramedullary fixation can decrease the incidence of internal fixation failure and speed up fracture healing, enabling patients to weight bear earlier. Meanwhile, complications such as venous thrombosis, bedsores, respiratory tract infections, and urinary tract infections are also significantly reduced [40]-[42].

We think that the application of cerclage cables has the following advantages: (1) It is conducive to fracture reduction and maintenance of the reduction, so it is easy to establish the correct intramedullary nail tunnel and insert the intramedullary nail. (2) It is beneficial to increase the contact area of the cortical bone at the fracture end to accelerate fracture healing and decrease the incidence of fracture nonunion. (3) It is beneficial to improve the intensity of the internal fixation and enable patients to start walking earlier. (4) It helps to facilitate stress transfer between the bone and the internal fixation, which reduces complications.

Our suggestions for using cerclage cables are as follows: (1) The placement position of the cerclage wire during the operation needs to be judged accurately. To avoid being impacted, the screws should be placed in the head and neck. (2) The cerclage cable should be inserted with the assistance of a cerclage cable guide, without excessive stripping of the soft tissue, in particular the medial soft tissue, so as to not damage the blood vessels and adversely affect fracture healing.

Conclusion

In summary, we believe that the application of cerclage cables are useful in fracture reductions and the maintenance of the reduction. It was found that PFNA combined with a cerclage cable improved the stability of the fracture reduction, shortened the postoperative weight-bearing time and fracture healing time, significantly improved patients' ability to self-care, and reduced the incidence of complications. Therefore, we believe that PFNA combined with a cerclage cable is a good choice for patients with unstable intertrochanteric fractures, and we recommend that orthopedic surgeons use cerclage cables in such procedures. This surgical technique is worthy of promotion and application in clinical practice.

Abbreviations

PFNA, proximal femoral nail antirotation; HHS, Harris hip score; BI, Barthel Index; RUSH, Radiographic Union Scale for Hip; AO/OTA, AO Foundation/Orthopaedic Trauma Association; DHS, dynamic hip screw; ADL, Activities of daily living; BMI, body mass index; VSD, ventricular septal defect;

Declarations

Authors'contributions

Xing Wu conceived of the idea presented. Qingchao Huang and Xing Wu designed the clinical research protocol. Qingchao Huang collected the clinical data, analyzed the data, explained the statistical analysis results, and completed the writing of the manuscript.

Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The patients and/or family members were informed of the purpose and nature of this study, and written informed consent was obtained. Our clinical study complies with the provisions of the ethics committee of Shanghai Tenth People's Hospital, School of Medicine, Tongji University, China.

Consent for publication

Not applicable.

Competing interests

The authors have no conflicts of interest to declare.

References

1. Kani KK, Porrino JA, Mulcahy H, et al. Fragility fractures of the proximal femur: review and update for radiologists. Skeletal Radiol.2019;48(1):29-45.
2. Zhao F, Wang X, Dou Y, et al. Analysis of risk factors for perioperative mortality in elderly patients with intertrochanteric fracture. Eur J Orthop Surg Traumatol.2019;29(1):59-63.
3. Zhang J, Chen X, Wang J, et al. Poor prognosis after surgery for intertrochanteric fracture in elderly patients with clopidogrel treatment: A cohort study. Medicine (Baltimore).2017;96(39):e8169.
4. Soo CG, Della Torre PK, Yolland TJ. et al. Clopidogrel and hip fractures, is it safe? A systematic review and meta-analysis. BMC Musculoskelet Disord.2016;17:136.
5. Meinberg EG, Agel J, Roberts CS, et al. Fracture and dislocation classification compendium—2018. J Orthop Trauma.2018;32 Suppl 1:S1-S170.
6. Shi H, Xiao L, Wang Z. Curative effect of artificial femoral head replacement and its effect on hip joint function and complications of senile patients with femoral intertrochanteric fracture. Exp Ther Med.2018;16(2):623-8.
7. Xu R, Ru J, Ji F, et al. Comparison of efficacy, complications and TGF-β2 expression between DHS and PFNA in elderly patients with osteoporotic femoral intertrochanteric fracture. Exp Ther Med.2018;16(1):394-99.

8. Xu YZ, Geng DC, Mao HQ, et al. A comparison of the proximal femoral nail antirotation device and dynamic hip screw in the treatment of unstable pertrochanteric fracture. J Int Med Res.2010;38(4):1266-75.
9. Trikha V, Das S, Agrawal P, et al. Role of percutaneous cerclage wire in the management of subtrochanteric fractures treated with intramedullary nails. Chin J Traumatol.2018;21(1):42-9.
10. Harris WH.Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty: an end-result study using a new method of result evaluation. J Bone Joint Surg Am.1969;51(4):737-55.
11. Chiavaras MM, Bains S, Choudur H, et al. The Radiographic Union Score for Hip (RUSH): the use of a checklist to evaluate hip fracture healing improves agreement between radiologists and orthopedic surgeons. Skeletal Radiol.2013;42(8):1079-88.
12. MAHONEY FI, BARTHEL DW.. FUNCTIONAL EVALUATION: THE BARTHEL INDEX. Md State Med J.1965;14:61-5.
13. Afsari A, Liporace F, Lindvall E, et al. Clamp-assisted reduction of high subtrochanteric fractures of the femur.J Bone Joint Surg Am.2009;91(8):1913-8.
14. Kulkarni SG, Babhulkar SS, Kulkarni SM, et al. Augmentation of intramedullary nailing in unstable intertrochanteric fractures using cerclage wire and lag screws: a comparative study. 2017;48 Suppl 2:S18-S22.
15. Apivatthakakul T, Phornphutkul C.Percutaneous cerclage wiring for reduction of periprosthetic and difficult femoral fractures. A technical note. 2012;43(6):966-71.
16. 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;56:250-5.
17. Hoskins W, Bingham R, Joseph S, et al. Subtrochanteric fracture: the effect of cerclage wire on fracture reduction and outcome. 2015;46(10):1992-5.
18. Tomás J, Teixidor J, Batalla L, et al. Subtrochanteric fractures: treatment with cerclage wire and long intramedullary nail. J Orthop Trauma.2013;27(7):e157-60.
19. Ban I, Birkelund L, Palm H, et al. Circumferential wires as a supplement to intramedullary nailing in unstable trochanteric hip fractures: 4 reoperations in 60 patients followed for 1 year. Acta Orthop.2012;83(3):240-3.
20. Angelini A, Battiato C. Combination of low-contact cerclage wiring and osteosynthesis in the treatment of femoral fractures. Eur J Orthop Surg Traumatol.2016;26(4):397-406.
21. Müller T, Topp T, Kühne CA, et al.The benefit of wire cerclage stabilisation of the medial hinge in intramedullary nailing for the treatment of subtrochanteric femoral fractures: a biomechanical study. Int Orthop.2011;35(8):1237-43.
22. Gao YS, Guo YJ, Yu XG, et al. A novel cerclage wiring technique in intertrochanteric femoral fractures treated by intramedullary nails in young adults. BMC Musculoskelet Disord.2018;19(1):359.

23. Perren SM, Fernandez Dell'Oca A, Lenz M, et al. Cerclage, evolution and potential of a Cinderella technology. An overview with reference to periprosthetic fractures. Acta Chir Orthop Traumatol Cech.2011;78(3):190-9.
24. Apivatthakakul T, Phaliphot J, Leuvitoonvechkit S. Percutaneous cerclage wiring, does it disrupt femoral blood supply? A cadaveric injection study. 2013;44(2):168-74.
25. Kennedy MT, Mitra A, Hierlihy TG, et al. Subtrochanteric hip fractures treated with cerclage cables and long cephalomedullary nails: a review of 17 consecutive cases over 2 years. 2011;42(11):1317-21.
26. Giannicola G, Sacchetti FM, Antonietti G, et al. Radial head, radiocapitellar and total elbow arthroplasties: a review of recent literature. 2014;45(2):428-36.
27. Herz-Ruelas ME, Gómez-Flores M, Moxica-Del Angel J, et al. Ulcerated radiodermatitis induced after fluoroscopically guided stent implantation angioplasty. Case Rep Dermatol Med.2014;2014:768624.
28. Reichel LM, Milam GS, Hillin CD, et al. Osteology of the coronoid process with clinical correlation to coronoid fractures in terrible triad injuries. J Shoulder Elbow Surg.2013;22(3):323-8.
29. Adams JE, Sanchez-Sotelo J, Kallina CF 4th, et al. Fractures of the coronoid: morphology based upon computer tomography scanning. J Shoulder Elbow Surg.2012;21(6):782-8.
30. Mellema JJ, Doornberg JN, Dyer GS, et al. Distribution of coronoid fracture lines by specific patterns of traumatic elbow instability. J Hand Surg Am.2014;39(10):2041-6.
31. Sormaala MJ, Sormaala A, Mattila VM, et al. MDCT findings after elbow dislocation: a retrospective study of 140 patients.Skeletal Radiol.2014;43(4):507-12.
32. Yong WJ, Tan J, Adikrishna A, et al. Morphometric analysis of the proximal ulna using three-dimensional computed tomography and computer-aided design: varus, dorsal, and torsion angulation. Surg Radiol Anat.2014;36(8):763-8.
33. Mereddy P, Kamath S, Ramakrishnan M, et al. The AO/ASIF proximal femoral nail antirotation (PFNA): a new design for the treatment of unstable proximal femoral fractures. 2009;40(4):428-32.
34. Simmermacher RK, Ljungqvist J, Bail H, et al. The new proximal femoral nail antirotation (PFNA) in daily practice: results of a multicentre clinical study. 2008;39(8):932-9.
35. McKee MD, Schemitsch EH, Sala MJ, et al. The pathoanatomy of lateral ligamentous disruption in complex elbow instability. J Shoulder Elbow Surg.2003;12(4):391-6.
36. Karuppiah SV, Knox D. Elbow dislocation with complete triceps avulsion. Case Rep Orthop.2014;2014:636504.
37. Pazzaglia UE, Congiu T, Raspanti M, et al. Anatomy of the intracortical canal system: scanning electron microscopy study in rabbit femur. Clin Orthop Relat Res.2009;467(9):2446-56.
38. Finsen V. The effect of cerclage wires on the strength of diaphyseal bone. 1995;26(3):159-61.
39. Huang P, Tang PF, Yao Q, et al. [A comparisive study between intramedullary interlocking nail and plate-screw fixation in the treatment of tibial shaft fractures]. Zhongguo Gu Shang.2008;21(4):261-3.

40. Micic ID, Mitkovic MB, Park IH, et al. Treatment of subtrochanteric femoral fractures using Selfdynamisable internal fixator. Clin Orthop Surg.2010;2(4):227-31.

41. Parker MJ, Handoll HH. Gamma and other cephalocondylic intramedullary nails versus extramedullary implants for extracapsular hip fractures in adults. Cochrane Database Syst Rev.2010;(9):CD000093.

42. Bojan AJ, Beimel C, Speitling A, et al.3066 consecutive Gamma Nails. 12 years experience at a single centre. BMC Musculoskelet Disord.2010;11:133.

Figures

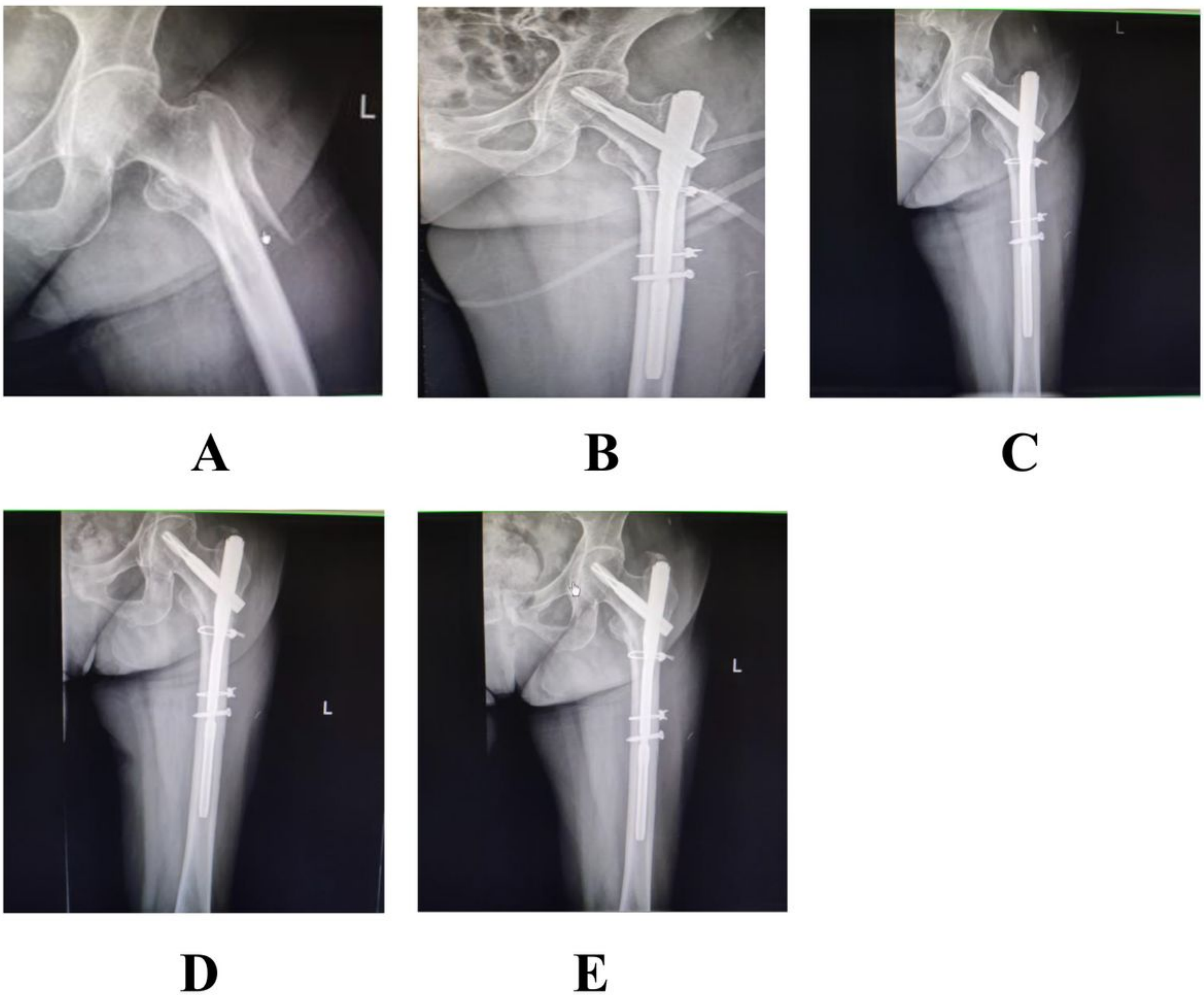

Figure 1

Preoperative and postoperative radiographic data of a patient with a reverse oblique intertrochanteric fracture treated with proximal femoral nail antirotation (PFNA) combined with a cerclage cable. Figure notes: A. Preoperative; B. One month after the operation; C. Three months after the operation; D. Six months after the operation; E. Twelve months after the operation

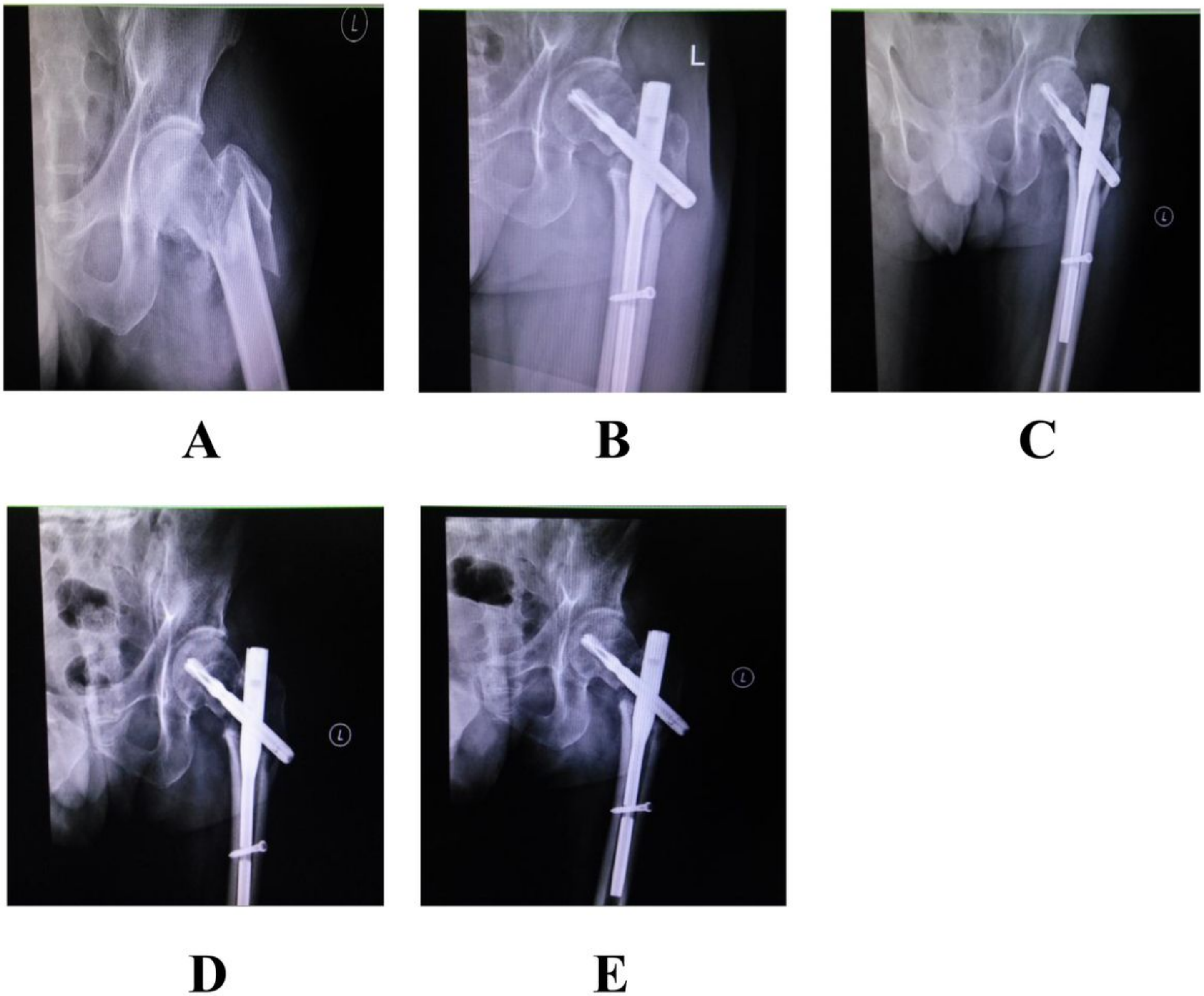

Figure 2

Preoperative and postoperative radiographic data of a patient with a reverse oblique intertrochanteric fracture treated with proximal femoral nail antirotation (PFNA). Figure notes: A. Preoperative; B. One month after the operation; C. Three months after the operation; D. Six months after the operation; E. Twelve months after the operation

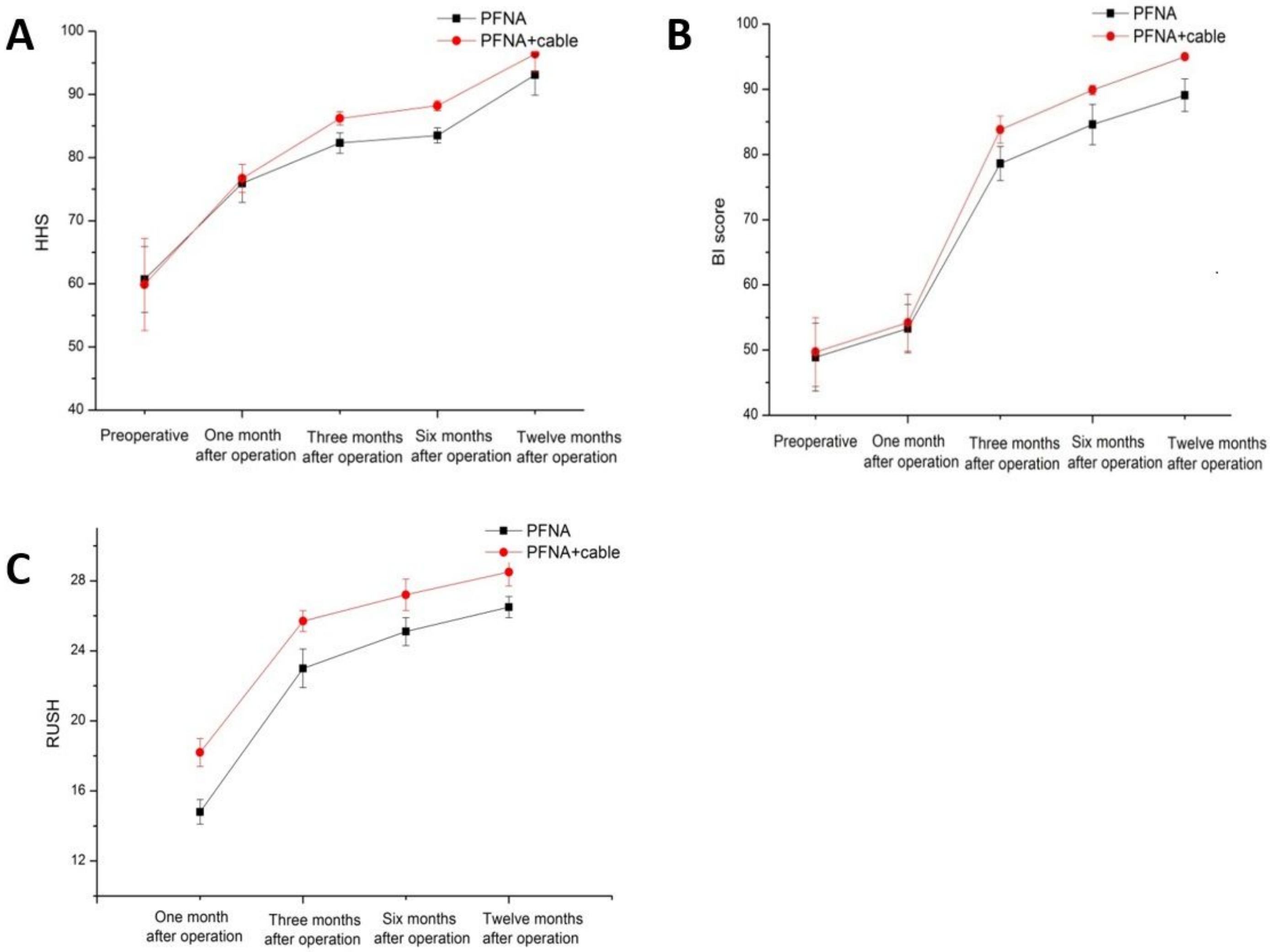

Figure 3

Comparison of the Harris hip score (HHS), Barthel Index (BI), and Radiographic Union Scale for Hip (RUSH) between the two groups Figure notes: A. HHS; B. BI; C. RUSH