

The Clinical Efficacy and Prognostic Impact of Intramedullary Nail Combined With Either Plates or Titanium Cable Internal Fixation in the Treatment of Femoral Subtrochanteric Fractures

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AIM: This study aims to compare the clinical efficacy of intramedullary nail combined with plate and intramedullary nail combined with titanium cable approaches in the treatment of femoral subtrochanteric fractures.

METHODS: This retrospective analysis included 85 patients who underwent treatment with intramedullary nails combined with plates and titanium cables at Shengzhou People's Hospital between January 2018 and December 2024. Among them, 40 cases received intramedullary nails combined with plates (the plate group) and 45 cases received intramedullary nails combined with titanium cables (the titanium cable group). Clinical data were collected and compared between the two groups of patients, which included surgery duration, length of hospital stay, incision length, blood loss, fluoroscopy time, fracture healing time, follow-up duration, time to first full weight bearing after surgery, quality of fracture reduction, changes in the neck-shaft angle, complications, and Harris Hip Score.

RESULTS: In the titanium cable group, both the incision length and intraoperative blood loss were superior to those in the plate group ($p < 0.05$). Conversely, the fluoroscopy time and fracture-healing time in the plate group were better than those in the titanium cable group ($p < 0.05$). Furthermore, both surgical time and length of hospital stay were significantly shorter in the titanium cable group than in the plate group; however, this difference did not achieve statistical significance ($p > 0.05$). Moreover, there were no significant differences in follow-up duration or time to first full weight-bearing between the two groups ($p > 0.05$). In the plate group, 2 cases were presented with postoperative complications (5.00%), including 1 case of cerebral infarction and 1 case of deep vein thrombosis. In the titanium cable group, 6 cases had postoperative complications (13.33%), which included 3 cases of delayed varus, 1 case of delayed healing, 1 case of acute coronary syndrome (ACS) combined with delayed varus, and 1 case of nonunion. However, the difference in the overall incidence of postoperative complications between the two groups was not statistically significant ($\chi^2 = 0.886, p = 0.347$). Additionally, no statistically significant differences were observed in the quality of fracture reduction and changes in the neck-shaft angle between the two groups ($p > 0.05$). Similarly, the Harris Hip Score at the last follow-up between the two groups did not differ significantly ($\chi^2 = 2.011, p = 0.156$).

CONCLUSIONS: Internal fixation with intramedullary nails combined with titanium cables for unstable femoral subtrochanteric fractures offers advantages of a smaller incision length and less intraoperative blood loss. In contrast, internal fixation with intramedullary nails combined with locking plates requires less fluoroscopy time, faster fracture healing, and fewer complications. Both approaches have specific strengths and limitations, providing promising guidance for surgical decision-making and achieving favorable outcomes.

Keywords: femoral subtrochanteric fracture; intramedullary nail; titanium cable; plate; efficacy

Introduction

Femoral subtrochanteric fractures are a common type of hip fracture [1], accounting for 10%–34% of all cases [2]. Specifically, these fractures occur between the upper margin of the lesser trochanter and the narrow part of the femur, primarily caused by low-energy injuries in elderly patients, whereas in younger individuals, they are more often the re-

sult of high-energy direct trauma such as traffic accidents or falls from heights [3]. The distinctive anatomical structure of femoral subtrochanteric fractures contributes to their complexity. Proximal fractures are prone to abduction by the gluteus medius and minimus muscles, and by the iliopsoas muscle, causing flexion and external rotation. Simultaneously, the distal fragment is pulled inward by the adductor muscles, making reduction technically challenging. The stability of these fractures largely depends on the high mechanical stresses in the subtrochanteric region and the integrity of the medial cortex [4]. Despite advances in surgical management, postoperative complications in femoral subtrochanteric fractures remain common. These include delayed union, nonunion, and mechanical failure of internal fixation devices [5].

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For even experienced orthopedic surgeons, femoral subtrochanteric fractures remain a challenge due to the distinct anatomical characteristics of this region, including the transition from cancellous to cortical bone, high stress concentration, and multiple muscle attachment points, all of which complicate surgical intervention. Currently, surgical treatment is the standard management option for femoral subtrochanteric fractures, as it effectively achieves fracture reduction and fixation, reduces the risk of complications, and significantly enhances the quality of life for patients [6]. The choice between extramedullary and intramedullary fixation depends on the fixation strategy [7]. The effectiveness of extramedullary fixation is largely influenced by medial stability. However, with ongoing advancements in internal fixation devices and evolving surgical concepts, the role of medial cortex integrity has become less significant in surgical decision-making than in the past [6]. Strong internal fixation approaches provide strong stabilization, promote healing, and protect adjacent soft tissue structures [8]. Currently, in cases where closed reduction fails, minimally invasive open reduction combined with intramedullary nail fixation is widely recognized as an effective treatment option for managing femoral subtrochanteric fractures [9,10]. However, intramedullary nails may not always provide sufficient stability, particularly in severely displaced or comminuted fractures [11], where the mechanical requirements of fixation are higher. To address this limitation, the combination of intramedullary nails with reconstruction plates has been widely adopted for the treatment of unstable femoral subtrochanteric fractures [12,13].

Previous evidence has revealed that intramedullary nails combined with additional locking plates can improve the quality of fracture reduction, reduce the time to full weight bearing and healing, and facilitate the recovery of hip joint function [14]. Similarly, the combination of intramedullary nails with titanium cable-assisted internal fixation has been found to enhance the success rate of reduction and increase the stability of fixation, thereby enabling earlier initiation of functional rehabilitation [15]. These observations underscore the clinical significance of adopting intramedullary nails with either locking plates or titanium cables-assisted internal fixation as effective surgical approaches for femoral subtrochanteric fractures.

This retrospective study aims to evaluate the potential clinical efficacy of intramedullary nails combined with locking plates and intramedullary nails combined with titanium cables in the management of femoral subtrochanteric fractures. Baseline features, perioperative indicators, and follow-up outcomes of the two methods (additional steel plates and additional titanium cables) were compared to provide evidence-based guidance for selecting appropriate surgical procedures for treating femoral subtrochanteric fractures in clinical practice.

Methods

Research Design and Recruitment of the Study Participants

This study retrospectively analyzed clinical data of 85 patients with unstable femoral subtrochanteric fractures who underwent surgical treatment at Shengzhou People's Hospital between January 2018 and December 2024. Inclusion criteria for patient selection were as follows: (1) age >16 years with confirmed skeletal maturity; (2) closed fractures; (3) confirmed diagnosis of unstable femoral subtrochanteric fracture. The exclusion criteria included (1) pathological fractures, (2) open fractures, (3) ipsilateral proximal femoral fractures or prior surgical history, and (4) patients with severe comorbidities hindering surgical tolerance.

Study participants were divided into two groups based on the treatment method: intramedullary nailing combined with a reconstruction locking plate (plate group) and intramedullary nailing with a titanium cable (titanium cable group). Surgical treatment was performed after stabilization of the patients' overall general condition.

All patients and their families provided informed consent for the study. The study was approved by the Institutional Review Board of Shengzhou People's Hospital (No: SZRY-REC-2025(010)) and was conducted in accordance with the Helsinki Declaration.

Surgical Technique

In the plate group, spinal or epidural anesthesia was administered, and patients were placed in a supine position. Closed reduction was initially attempted by applying slow traction with external rotation and abduction, followed by relaxation with internal abduction and rotation. Under fluoroscopic guidance, the position of the proximal femur was confirmed, and a lateral proximal femoral incision was then made to expose the fracture site. Reduction of the distal fracture was achieved using appropriate traction and rotation, combined with auxiliary techniques and tools such as the Joystick technique, Schanz screws, and bone hooks, while carefully maintaining the integrity of the medial cortex. After adequate fracture reduction, temporary fixation was performed with Kirschner wires. A locking plate was then placed on the anterolateral or posterolateral aspect of the femur, with 2–3 unicortical screws (8–10 mm in length) inserted proximally and distally. The position and length of the plate and screws were confirmed under fluoroscopy. The intramedullary nail entry point was selected based on the type of fracture and implant design, either at the piriformis fossa or the tip of the greater trochanter. Under fluoroscopic guidance, the length and position of the intramedullary nail and locking screws were confirmed. The intramedullary nail was advanced slowly to minimize displacement of the fracture fragments.

In the titanium cable group, spinal or epidural anesthesia was administered, and patients were placed in the supine position. The initial steps were the same as those in the

Table 1. Baseline characteristics of the plate and titanium groups.

Parameter	Plate group (n = 40)	Titanium cable group (n = 45)	Z/ χ^2	p-value
Age	64.00 (53.75, 74.25)	70.00 (51.00, 79.50)	-1.136	0.256
Gender (n (%))			2.477	0.116
Male	28 (70.00)	24 (53.33)		
Female	12 (30.00)	21 (46.67)		
Seinsheimer type (cases)			3.116	0.211
I	0 (0.00)	0 (0.00)		
II	0 (0.00)	0 (0.00)		
III	6 (15.00)	12 (26.67)		
IV	7 (17.50)	11 (24.44)		
V	27 (67.50)	22 (48.89)		

plate group. After fracture reduction, temporary fixation was achieved with Kirschner wires, and the fracture site was then secured using a titanium cable binding system. The wound was sutured, and an intramedullary nail was then inserted following the same method as applied in the plate group.

Data Collection

During the study period, we collected the following data: demographic characteristics (age, gender, and Seinsheimer classification [16]), surgical indicators (surgical time, incision length, blood loss, and fluoroscopy time), length of hospital stay, postoperative outcomes (fracture healing time, follow-up duration, and time to full weight-bearing), radiographic evaluations (quality of fracture reduction and changes in neck-shaft angle), and complications (including cerebral infarction, deep vein thrombosis, delayed varus, delayed healing, acute coronary syndrome (ACS) combined with delayed varus, and nonunion). The quality of fracture reduction was categorized into three levels: excellent, good, and poor [17,18].

In brief, the criteria for fracture reduction quality was designated as follows: “excellent”, anatomical restoration with superior alignment; “good”, fragment displacement ≤ 1 cm with angulation less than 10° , enabling slight internal and external rotation or minor anterior-posterior angular deformities; and “poor”, fragment displacement exceeding 1 cm, along with angulation surpassing 10° , including substantial rotational or pronounced anterior-posterior angular deformities.

At the final follow-up, hip joint function was evaluated using the Harris Hip score [19]. This evaluation includes four domains: pain (44 points), function (47 points), deformity (4 points), and range of motion (5 points), for a maximum score of 100. A total score of 90–100 was classified as excellent, 80–89 as good, 70–79 as fair, and below 69 as poor.

Postoperative Treatment

Anti-inflammatory and analgesic treatments were administered within 24 to 48 hours after surgery. Patients were encouraged to perform active and passive hip and knee joint

exercises after 48 hours. From the 2nd postoperative week onward, progressive weight-bearing training was initiated, with full weight-bearing training conducted according to the fracture healing status.

Statistical Analysis

Data were statistically analyzed using SPSS 25.0 (IBM Corp., Armonk, NY, USA). Data normality was evaluated using the Kolmogorov-Smirnov test. Normally distributed measurement data were expressed as the mean $\pm$ standard deviation ($\bar{x} \pm s$), and intergroup comparisons were performed using the independent samples *t*-test. Non-normally distributed measurement data were expressed as median and interquartile range [M (P25, P75)] and analyzed using the rank-sum test. However, categorical variables were analyzed using the χ^2 test. A *p*-value of <0.05 was considered statistically significant.

Results

Comparison of Baseline Characteristics Between the Two Study Groups

This retrospective study included 85 cases, with 40 cases in the plate group and 45 cases in the titanium cable group. There were no significant differences in age, gender, or Seinsheimer type between the two groups ($p > 0.05$). The baseline characteristics of both groups are detailed in Table 1.

Comparison of Perioperative Observation Indicators Between the Two Groups

In the titanium cable group, both blood loss and incision length were substantially lower than those in the plate group ($p < 0.05$). However, no significant differences were observed in surgical time or length of hospital stay between the two groups ($p > 0.05$). Furthermore, fluoroscopy time was significantly lower in the plate group than in the titanium cable group ($p < 0.05$). Perioperative observation indicators for both groups are shown in Table 2.

Table 2. Perioperative observation indicators of patients with femoral subtrochanteric fractures in the plate and titanium cable groups.

Parameter	Plate group (n = 40)	Titanium cable group (n = 45)	Z	p-value
Surgical time (mins)	130.00 (120.00, 147.50)	122.00 (112.50, 146.00)	-1.408	0.159
Length of hospital stay (days)	18.00 (15.00, 25.00)	17.00 (15.00, 23.00)	-0.574	0.566
Length of incision (cm)	20.00 (16.25, 22.75)	14.00 (12.00, 19.00)	-4.467	<0.001
Blood loss (mL)	600.00 (500.00, 700.00)	400.00 (300.00, 575.00)	-3.62	<0.001
Fluoroscopy time (number)	20.50 (19.25, 25.00)	25.00 (20.00, 34.00)	-3.508	<0.001
Follow-up (months)	14.00 (9.00, 18.00)	12.00 (11.00, 16.50)	-0.166	0.869
Fracture healing time (weeks)	15.00 (12.25, 16.00)	18.00 (16.00, 19.50)	-5.566	<0.001
First full weight-bearing (months)	4.00 (4.00, 4.00)	4.00 (4.00, 5.00)	-1.188	0.235

Outcomes of the Patient Follow-Up Assessment

All study participants (n = 85) were followed for 6 to 18 months, with no significant difference in follow-up duration between the two groups ($p > 0.05$). The fracture healing time was considerably shorter in the plate group than in the titanium cable group ($p < 0.05$). Postoperatively, no significant difference was observed in the time to first full weight-bearing between the two groups ($p > 0.05$, Table 2). Furthermore, based on the fracture reduction assessment criteria, the excellent rate of fracture reduction quality was 82.50% in the plate group and 73.33% in the titanium cable group, with no statistically significant difference ($p > 0.05$) (Table 3). During the first postoperative radiographic (X-ray) examination, no significant difference was found in the neck-shaft angle between the two groups ($p > 0.05$). At the final follow-up, the plate group showed a better neck-shaft angle than the titanium cable group, although the difference was not statistically significant ($p > 0.05$, Table 4). In terms of postoperative complications, the plate group had 2 cases (5.00%): 1 case of cerebral infarction and 1 deep vein thrombosis. In contrast, the titanium cable group had 6 cases of postoperative complications (13.33%), including 3 cases of delayed varus, 1 case of delayed healing, 1 case of ACS with delayed varus, and 1 case of nonunion. The overall incidence of postoperative complications did not differ significantly between the two groups ($\chi^2 = 0.886$, $p = 0.347$) (Table 5). However, at the final follow-up, no significant difference was observed in Harris hip function scores between the plate group and the titanium cable group ($p > 0.05$, Table 6).

Representative cases for both groups are shown in Figs. 1,2. Fig. 1 depicts two cases with unstable femoral subtrochanteric fractures treated with intramedullary nailing combined with reconstruction locking plates. In case A, preoperative X-ray revealed a right femoral subtrochanteric fracture with significant separation and displacement. At 1 week after the operation, X-ray imaging showed satisfactory fracture reduction with stable internal fixation. At one year follow-up, the fracture line had nearly disappeared, indicating successful fracture healing. In case B, preoperative X-ray revealed a right femoral subtrochanteric fracture with significant separation and displacement. At 1 week

Table 3. Comparison of fracture reduction quality between the two groups of patients with femoral subtrochanteric fractures.

Group	Excellent	Good	Poor
Plate group (n = 40)	33 (82.50)	7 (17.50)	0 (0.00)
Titanium cable group (n = 45)	33 (73.33)	7 (15.56)	5 (11.11)
χ^2	4.722		
p-value	0.094		

after the operation, X-ray imaging confirmed good fracture reduction and stable internal fixation. At six months postoperatively, the fracture line had essentially disappeared, indicating good fracture healing.

Fig. 2 illustrates two cases of unstable femoral subtrochanteric fractures treated with intramedullary nailing combined with titanium cables. In case A, the preoperative X-ray showed a left femoral subtrochanteric fracture with significant separation and displacement. At 1 week after the operation, X-ray imaging revealed good fracture reduction with stable internal fixation. However, at eight months of follow-up, X-ray imaging revealed good fracture healing. In case B, preoperative X-ray imaging showed a left femoral subtrochanteric fracture with significant separation and displacement. However, satisfactory reduction was confirmed at 1 week after the operation. Furthermore, at 1-year follow-up, the fracture line had nearly disappeared, suggesting successful and solid fracture healing.

Discussion

Femoral subtrochanteric fractures possess unique anatomical characteristics that predispose them to displacement, making conservative treatment largely ineffective; therefore, surgical treatment remains the standard management approach. However, there is still controversy regarding the optimal internal fixation strategy and surgical methods [20,21]. Open reduction combined with internal fixation allows for direct observation of the fracture site, thereby facilitating a faster and more accurate reduction. Wang *et al.* [14] reported that limited open exposure of the fracture site not only improves reduction accuracy but also helps to protect the blood supply, without significantly increasing

Table 4. Changes in neck-shaft angle across the two groups.

Group	Neck-shaft angle at first postoperative (°)	Last follow-up neck-shaft angle (°)
Plate group (n = 40)	130.00 (128.00, 132.50)	129.00 (127.25, 134.50)
Titanium cable group (n = 45)	130.00 (128.00, 134.00)	128.00 (126.00, 131.50)
Z	-0.759	-1.090
p-value	0.448	0.276

Table 5. Comparison of postoperative complications between the two groups of patients.

Group	Cerebral infarction	Deep venous thrombosis	Delayed varus	Delayed healing	ACS combined with delayed varus	Nonunion	Overall incidence rate
Plate group (n = 40)	1 (2.50)	1 (2.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (5.00)
Titanium cable group (n = 45)	0 (0.00)	0 (0.00)	3 (6.67)	1 (2.22)	1 (2.22)	1 (2.22)	6 (13.33)
χ^2							0.886
p							0.347

ACS, acute coronary syndrome.

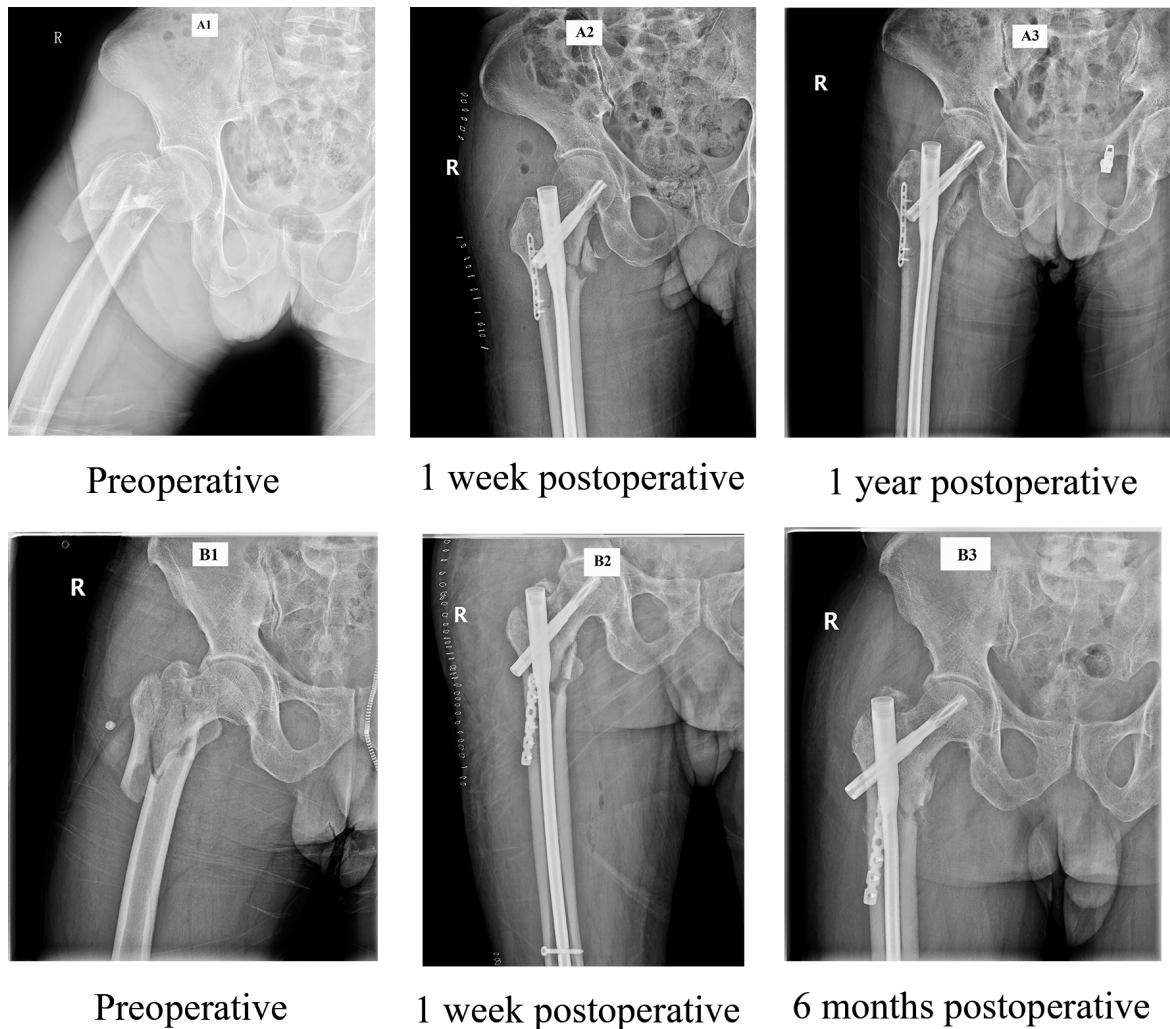


Fig. 1. Two cases of unstable femoral subtrochanteric fractures treated with intramedullary nailing combined with reconstruction locking plates. (A1) Preoperative. (A2) 1 week postoperative. (A3) 1 year postoperative. (B1) Preoperative. (B2) 1 week postoperative. (B3) 6 months postoperative. R, right.

Table 6. Comparison of final Harris Hip Score between the two groups.

Group	Excellent	Good	General	Poor	Excellence rate
Plate group (n = 40)	5 (12.50)	34 (85.00)	1 (2.50)	0 (0.00)	39 (97.50)
Titanium cable group (n = 45)	6 (13.33)	33 (73.33)	6 (13.33)	0 (0.00)	39 (86.67)
χ^2	2.011				
<i>p</i> -value	0.156				

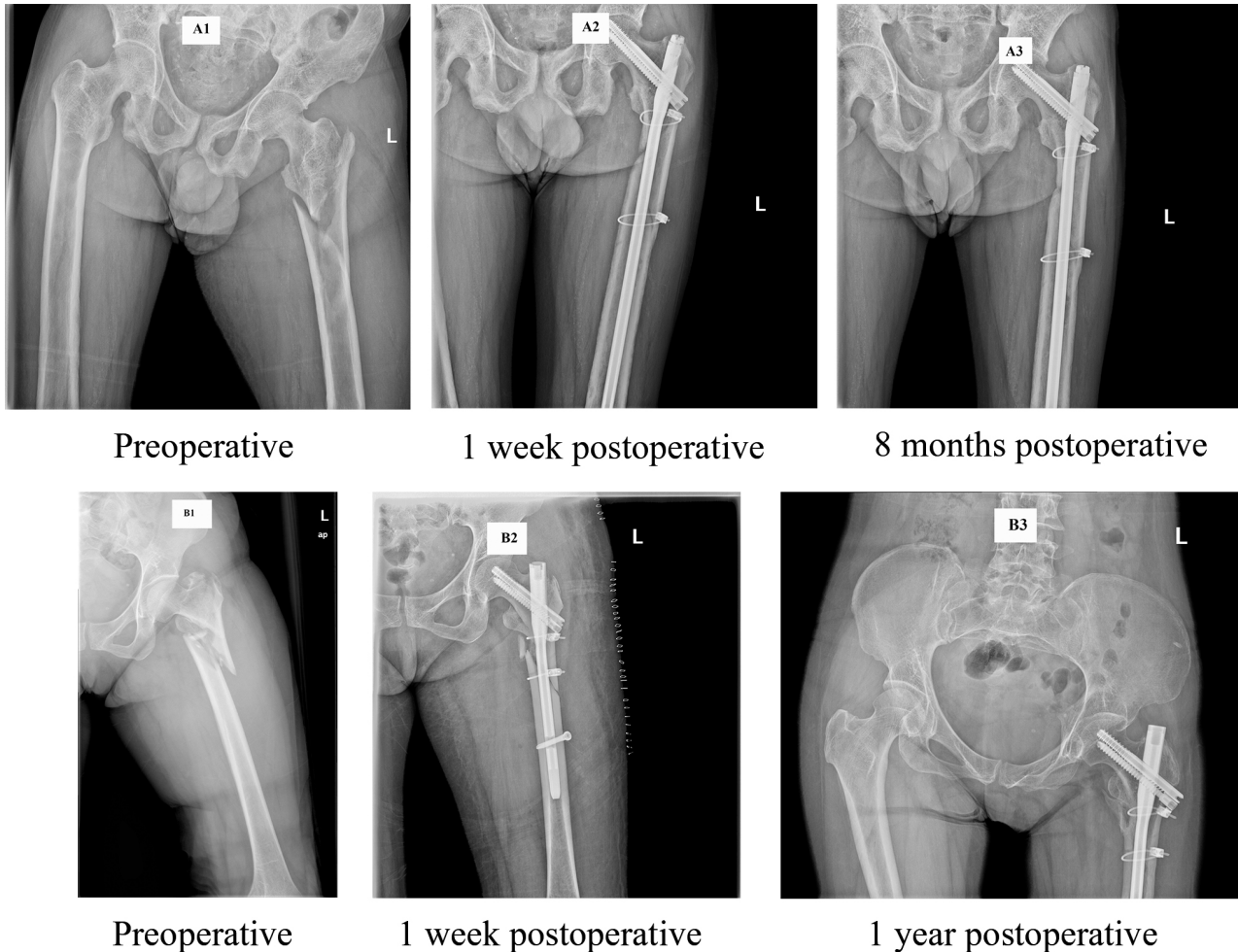


Fig. 2. Two cases of unstable femoral subtrochanteric fractures treated with intramedullary nailing combined with titanium cables. (A1) Preoperative. (A2) 1 week postoperative. (A3) 8 months postoperative. (B1) Preoperative. (B2) 1 week postoperative. (B3) 1 year postoperative. L, left.

the risk of postoperative complications. Therefore, limited open reduction is considered the preferred choice for treating unstable femoral subtrochanteric fractures [22].

Intramedullary nailing is recognized as an optimal fixation approach for femoral subtrochanteric fractures, as this method aligns with the principles of minimally invasive surgery while reducing the risk of fracture varus and collapse. Additionally, this technique offers biomechanical advantages, including a shorter lever arm, improved load distribution, and reduced bending motion [23]. However, ensuring and maintaining precise fracture reduction both before and during nail insertion is crucial. To achieve

this, adjunctive fixation methods such as additional locking plates or supplementary titanium cables can be used to stabilize and maintain the reduction of unstable femoral subtrochanteric fractures.

Previously, it has been reported that intramedullary nailing combined with plate fixation enhances fracture stability, reduces micro-movement at the fracture ends, and decreases the mechanical load on the intramedullary nail [24]. Similarly, the addition of titanium cables achieves a 100% success rate in fracture reduction, with considerably less varus angle loss and shorter time to full weight-bearing after surgery than fixation without titanium cables [25]. How-

ever, it remains unclear whether the intramedullary nailing combined with titanium cables achieves superior clinical outcomes compared with intramedullary nailing combined with locking plates.

Intraoperatively, the use of titanium cables for looping was found to be both relatively convenient and flexible. Their supportive functions can be summarized as follows: (1) They can effectively fix more displaced bone fragments, whether reconstructing the lateral wall or stabilizing fragments displaced at the subtrochanteric level. (2) After assisting with reduction, the titanium cable offers stable fixation. Unlike relying on an assistant to hold the bone distractor or reduction clamp, the mechanical stability provided by cable bundling is firmer and more stable. This approach minimizes the need for repeated fluoroscopy to prevent loss of reduction, thereby reducing radiation exposure to the surgical staff. (3) Titanium cables effectively add an external supportive element to the internal fixation, creating an “internal-external holding” effect that ensures the maintenance of fracture reduction and reduces the risk of postoperative fracture displacement or implant loosening.

In elderly patients with osteoporotic complex intertrochanteric fractures, using titanium cable bundling offers effective reinforcement by aiding fracture reduction and maintenance before the insertion of the intramedullary nail, facilitating successful nail placement, ensuring strong postoperative fixation, simplifying the surgical operations, shortening the surgical duration, and minimizing intraoperative blood loss [26]. Consistent with our study, patients treated with the intramedullary nailing combined with titanium cables exhibited less blood loss, and smaller incision lengths compared with those who received intramedullary nailing combined with plates. Notably, this study also found that the plate group had a shorter fracture healing time compared to the additional titanium cable group, indicating that additional plate fixation can achieve better fracture reduction and enhanced stability. Our findings align with Xu *et al.* [27], who reported that additional plate fixation offers distinct advantages: (1) assisting and maintaining fracture reduction while reducing rotational stability at the fracture ends; and (2) serving as an internal stabilizer that reduces micro-movement at the fracture ends, thereby creating favorable conditions for primary fracture healing. This effect is particularly crucial for unstable femoral subtrochanteric fractures, where additional plate fixation can effectively alleviate fragment displacement and promote timely fracture healing [27].

In this study, no significant differences were found between the plates and titanium cable groups regarding time to full weight-bearing neck-shaft angle or fracture reduction quality for unstable femoral subtrochanteric fractures. Liu *et al.* [28] demonstrated that the combination of titanium cable looping with intramedullary nail fixation can effectively restore medial and lateral stability, achieve rapid overall stability, and support patients' early mobilization, thereby pro-

moting functional recovery. Furthermore, looping fixation reduces the gap between fracture ends, minimizing the risk of nonunion or poor healing and accelerating the early fracture healing process [28].

At the final follow-up, no patients with delayed fracture healing, non-healing fractures, delayed varus, or ACS combined with delayed varus were observed in the plate group. However, the titanium cable group had 1 case of delayed fracture healing, 1 case of non-healing fracture, 3 cases of delayed varus deformity, and 1 case of ACS combined with delayed varus deformity. Although there was no significant difference in the overall incidence of complications between the two groups, these findings still indicate that intramedullary nails combined with plate internal fixation can provide greater stability and better prevent varus angle loss. Furthermore, Harris Hip Score at the final follow-up showed no statistically significant difference between the two groups, indicating that the two fixation methods had a comparable impact on postoperative lower limb function. We acknowledge several limitations in this study. First, its retrospective design may cause inherent biases. Second, as the study was conducted at a single hospital, the generalizability and reliability of the findings may be limited. Third, the relative sample size may introduce selection bias. Fourth, due to the differences in the follow-up time, the results may be biased. Future research should include larger cohorts, multicenter prospective studies, and randomized controlled trials to improve the validity and reliability of the results. Such a study would enable a more accurate assessment of the clinical application of intramedullary nailing combined with plates or titanium cables in the management of femoral subtrochanteric fractures and provide strong guidance for clinical practice.

Conclusions

Intramedullary nail combined with additional titanium cable fixation for the treatment of unstable femoral subtrochanteric fractures offers advantages, including smaller incision length, and less intraoperative blood loss. In contrast, the use of intramedullary nailing combined with a locking plate results in less fluoroscopy time, faster fracture healing, and fewer complications. These observations indicate that both fixation methods have their distinct strengths and limitations, providing a valuable reference for surgical decision-making and future research in the clinical treatment of femoral subtrochanteric fractures.

Availability of Data and Materials

The data used and analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

LZ collected data and wrote the manuscript. XQZ wrote the article and collected data. GXW jointly participated the surgical operation. LZ had the initial idea for the study and is the guarantor. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Helsinki Declaration, and the protocol was approved by the Institutional Review Board of Shengzhou People's Hospital (No: SZRY-REC-2025(010)). All patients and their families provided informed consent for the study.

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Conflict of Interest

The authors declare no conflict of interest.

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