

Review Article

Efficacy comparison between plate fixation and elastic stable intramedullary nail in patients with tibial fracture and their postoperative knee joint function

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Abstract: Background: As a commonly used therapeutic method for fractures, plate fixation can cause soft tissue injury and hematoma disruption, so it is essential to seek a less invasive surgical method. Elastic stable intramedullary nail (ESIN) is a closed surgery for small wounds, and patients undergoing this surgery can bear weight and walk as soon as possible. This paper aimed to explore the application of ESIN in tibial fractures. Methods: One hundred hospitalized patients with tibial fracture in the department of orthopedics of our hospital from January 2018 to May 2019 were enrolled; in which 57 were treated with traditional plate fixation (Group A), whereas 43 were treated with ESIN (Group B). They were observed for their postoperative knee range of motion (KROM), inflammatory cytokine levels, adverse reactions, and quality of life. Results: Compared with those in Group A, patients in Group B had better operative conditions and better knee joint function ($P<0.05$), a lower postoperative incidence of adverse reactions and lower inflammatory cytokine levels ($P<0.05$), shorter healing time ($P<0.05$), and higher related quality of life scores ($P<0.05$). Conclusion: The application of ESIN in tibial fracture can reduce the occurrence of adverse reactions and promote joint recovery in patients.

Keywords: Plate fixation, ESIN, tibial fracture, efficacy, postoperative recovery, knee joint

Introduction

In recent years, an increase of trauma has led to a higher incidence of fractures that are treated by internal fixation. Tibial fracture is reported as one of the most common and complicated fractures and patients with this condition who have undergone surgical treatment are at risk of having severe and debilitating infections [1]. Tibial fracture mostly occurs in people aged 50-60 years old, with a similar incidence between men and women. In order to treat the fracture, it is necessary to obtain anatomical reduction of the joint surface and satisfactory internal fixation under the restriction of local soft tissues and blood supply [2]. Although open reduction and internal fixation (ORIF) techniques are a good method for joint shape recovery and biomechanics, they can cause a high incidence of soft tissue complications [3].

It is reported that the incidence of wound complications in young patients with tibia plateau fracture after ORIF is approximately 5% to 15%, so it is very necessary to explore a less invasive surgical method [4]. The use of intramedullary devices that have relative stability can cause a smaller incision, less soft tissue damage, and fixed load sharing; thus promoting the formation of a large callus. Elastic nails are a commonly used implant for intramedullary fixation devices [5]. Intramedullary nails can have a good internal splint effect and resist considerable rotary force [6]. Elastic stable intramedullary nail (ESIN) retains the periosteum and allows bone healing in a biological environment that is closed and complete. By using this method, which has a very low incidence of complications, where affected bone segments can be immediately stabilized at an early stage, and normal activities of the patients can occur as

soon as possibly [7]. ESIN meets all the criteria of minimally invasive bone surgery: shorter operative time, minimal soft tissue damage, and a smaller incision; as well as correspondingly smaller scars, less pain, and relatively easy implant removal [8]. Therefore, in this study, the application of ESIN in patients with tibial fracture was explored.

Materials and methods

General information

One hundred hospitalized patients with tibial fracture in the department of orthopedics of our hospital from January 2018 to May 2019 were enrolled. Among them, 57 were treated with traditional plate fixation (Group A), consisting of 32 males and 25 females, whose average age was (27.39±5.29) years old. The remaining 43 were treated with ESIN (Group B), consisting of 26 males and 17 females, whose average age was (28.65±6.23) years old.

Inclusion and exclusion criteria

Inclusion criteria: All patients were confirmed with tibial fracture by imaging [9]. This study was approved by the Medical Ethics Committee of The First Affiliated Hospital of Hebei North University. The patients and their families were informed of this study and signed the informed consent form.

Exclusion criteria: Patients with pathological, comminuted, or intra-articular fracture; patients complicated with osteofascial compartment syndrome, major neurovascular injury, or other malignant diseases.

Methods

AO instruments were used in all patients. Patients in Group A were treated with traditional plate fixation. With the tibial fracture end used as the center, an incision was made along the tibia to incise the skin, subcutaneous tissue, and fascia, so as to expose the fracture end. After blood clots were removed and traction reduction was performed, the AO anatomical steel plate was used to fix the fracture end. Finally, the operative area was washed, and the incision was closed layer by layer.

Patients in Group B were treated with ESIN. A longitudinal incision was made at 1 cm proximal

to the prominence of the lateral malleolus, and corresponding AO ESINs were inserted anterogradely according to the size of medullary cavity. If there was obvious displacement, the lateral longitudinal incision with a length of 2-3 cm was made for reduction and inserting elastic nails. The nail tail was bent, cut, and then buried subcutaneously. Finally, the incision was closed.

Post-operative treatment: All patients were administered with antibiotics for one day as prevention. One week after the operation, functional exercises conforming to the patients' own conditions could be performed. The patients underwent reexaminations monthly, and American Orthopedic Foot and Ankle Society (AOFAS) scores were used to observe the post-operative knee joint function.

Outcome measures

(1) The patients' knee range of motion (KROM [10]; maximum knee extension angle and maximum knee flexion angle) was observed one month after operation.

(2) Postoperative venous blood (5 mL) was drawn from patients in both groups; which was allowed to stand for 20 min, and then centrifuged in a centrifuge (10×g at 4°C for 15 min, Beijing BMH Instruments Co., Ltd.) to separate the serum, which was quickly frozen in liquid nitrogen and stored at -80°C for later use. Levels of interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α) were detected by enzyme-linked immunosorbent assay (ELISA) (Suzhou ELSBIO Biotechnology Co., Ltd.) according to the instructions.

(3) AOFAS scoring [11] was used to observe the postoperative knee joint function, with a full score of 100 points. A score between 90-100 points indicated excellent; a score between 80-89 points indicated acceptable; a score between 70-79 points indicated normal; a score <69 points indicated poor. Excellent rate = (excellent + acceptable cases)/total number of cases ×100%.

(4) 36-Item Short-Form Health Survey (SF-36) [12] was used to score the patients' quality of life, with a total score of 100 points. A high score indicated better QOL.

Application of ESIN in tibial fracture

Table 1. General information table ($\bar{x} \pm sd$) [n (%)]

| Categories | Group A (n=57) | Group B (n=43) | t/ χ^2 value | P value |
|-------------------------|-------------------|-------------------|----------------------|------------|
| Gender | | | 0.188 | 0.664 |
| Male | 32 (56.14) | 26 (60.47) | | |
| Female | 25 (43.86) | 17 (39.53) | | |
| Age (Years) | 27.39±5.29 | 28.65±6.23 | 1.092 | 0.277 |
| Body weight (kg) | 57.29±7.24 | 56.29±7.39 | 0.677 | 0.499 |
| Height (cm) | 174.29±2.57 | 175.32±3.12 | 1.809 | 0.073 |
| Nationality | | | 0.022 | 0.879 |
| Han | 43 (75.44) | 33 (76.74) | | |
| Ethnic minorities | 14 (24.56) | 10 (23.26) | | |
| Place of residence | | | 0.04 | 0.834 |
| City | 40 (70.18) | 31 (72.09) | | |
| Countryside | 17 (29.82) | 12 (27.91) | | |
| Educational history | | | 0.188 | 0.664 |
| ≥ Senior high school | 32 (56.14) | 26 (60.47) | | |
| < Senior high school | 25 (43.86) | 17 (39.53) | | |
| Economic conditions | | | 0.014 | 0.993 |
| Poor | 12 (21.05) | 9 (20.93) | | |
| General | 31 (54.39) | 23 (53.49) | | |
| Rich | 14 (24.56) | 11 (25.58) | | |
| History of diabetes | | | 0.636 | 0.425 |
| Yes | 4 (7.02) | 5 (11.63) | | |
| No | 53 (92.98) | 38 (88.37) | | |
| History of hypertension | | | 0.117 | 0.731 |
| Yes | 2 (3.51) | 1 (2.33) | | |
| No | 55 (96.49) | 42 (97.67) | | |
| Smoking | | | 0.020 | 0.887 |
| Yes | 35 (61.40) | 27 (62.79) | | |
| No | 22 (38.60) | 16 (37.21) | | |
| Drinking | | | 0.006 | 0.933 |
| Yes | 42 (73.68) | 32 (74.41) | | |
| No | 15 (26.32) | 11 (25.58) | | |
| Staying up | | | 0.496 | 0.481 |
| Yes | 46 (80.70) | 37 (86.05) | | |
| No | 11 (19.30) | 6 (13.95) | | |
| Exercise | | | 0.125 | 0.723 |
| Yes | 49 (85.96) | 38 (88.37) | | |
| No | 8 (14.04) | 5 (11.63) | | |
| Causes of fractures | | | 0.020 | 0.989 |
| Traffic accidents | 26 (45.61) | 19 (44.19) | | |
| Falling | 18 (31.58) | 14 (32.56) | | |
| Dropping | 13 (22.81) | 10 (23.26) | | |

Statistical methods

SPSS 21.0 (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. Measurement data were expressed by ($\bar{x} \pm sd$), and its com-

parison between groups was analyzed by t test. Count data were expressed by [n (%)], and chi-square test was used for comparison of count data between groups. $P < 0.05$ indicated a statistically significant difference.

Results

General information

There was no difference in general information between patients in Groups A and B ($P > 0.05$). See **Table 1** for details.

Comparison of operative conditions

The operative time was (123.28 ± 6.39) min in Group A and (121.47 ± 6.20) min in Group B. The incision length was (7.28 ± 1.59) cm in Group A and (3.19 ± 1.23) cm in Group B. The hospitalization time was (15.49 ± 3.28) d in Group A and (11.34 ± 2.94) d in Group B. The bleeding volume was (94.29 ± 10.21) mL in Group A and (42.48 ± 8.39) mL in Group B. The operative conditions were better in Group B ($P < 0.05$), but the operative time was not different between the two groups ($P > 0.05$). See **Figure 1** for details.

Comparison of postoperative KROM

The maximum knee extension angle was (-0.38 ± 0.03)° in Group A and (-0.73 ± 0.04)° in Group B. The maximum knee flexion angle was (105.31 ± 6.24)° in Group A and (129.24 ± 7.40)° in Group B. The two maximum angles were greater in Group B ($P < 0.05$). See **Table 2** for details.

Comparison of postoperative inflammatory cytokines

Postoperative IL-6 level was (84.29 ± 6.29) ng/L in Group A and (67.29 ± 5.13) ng/L in Group B. Postoperative TNF- α level was (73.28 ± 6.33)

Application of ESIN in tibial fracture

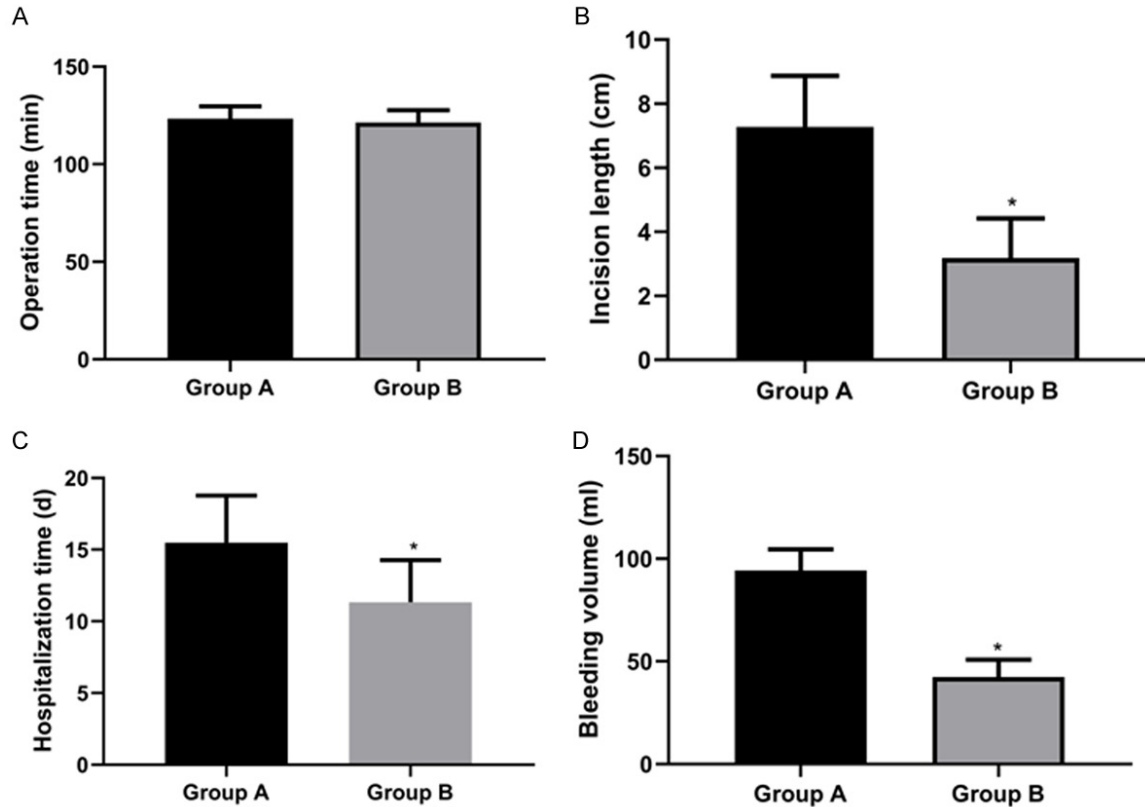


Figure 1. Comparison of operative conditions. A. There was no significant difference in operative time between Groups A and B ($P > 0.05$). Note: * indicates $P < 0.05$ when compared with Group A. B. The operative incision length was significantly shorter in Group B ($P < 0.05$). Note: * indicates $P < 0.05$ when compared with Group A. C. The hospitalization time was significantly shorter in Group B ($P < 0.05$). Note: * indicates $P < 0.05$ when compared with Group A. D. The intraoperative bleeding volume was significantly less in Group B ($P < 0.05$). Note: * indicates $P < 0.05$ when compared with Group A.

Table 2. Comparison of postoperative KROM ($\bar{x} \pm sd$)

| | n | Maximum knee extension angle ($^{\circ}$) | Maximum knee flexion angle ($^{\circ}$) |
|---------|----|---|---|
| Group A | 57 | -0.38 ± 0.03 | 105.31 ± 6.24 |
| Group B | 43 | -0.73 ± 0.04 | 129.24 ± 7.40 |
| t | | 50.020 | 17.520 |
| p | | < 0.001 | < 0.001 |

ng/L in Group A and (54.64 ± 4.69) ng/L in Group B. Postoperative IL-6 and TNF- α levels were lower in Group B ($P < 0.05$). See **Figure 2** for details.

Comparison of healing time

The healing time was (13.50 ± 2.69) weeks in Group A, longer than (10.67 ± 2.13) weeks in Group B ($P < 0.05$). See **Figure 3** for details.

Comparison of postoperative adverse reactions

The total incidence of adverse reactions was lower in Group B ($P < 0.05$). See **Table 3** for details.

Comparison of excellence of knee joint function recovery

The excellent rate was higher in Group B ($P < 0.05$). See **Table 4** for details.

Comparison of postoperative quality of life

The physical function score was (75.33 ± 4.32) points in Group A and (85.30 ± 5.43) points in Group B. The activity of daily living score was (83.19 ± 3.22) points in Group A and (92.11 ± 2.43) points in Group B. The psychological function score was (77.43 ± 4.32) points in

Application of ESIN in tibial fracture

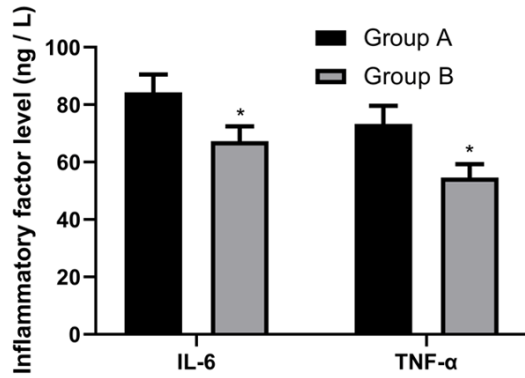


Figure 2. Comparison of postoperative inflammatory cytokines. Postoperative IL-6 and TNF- α levels were significantly lower in Group B ($P < 0.05$). Note: * indicates $P < 0.05$ when compared with Group A.

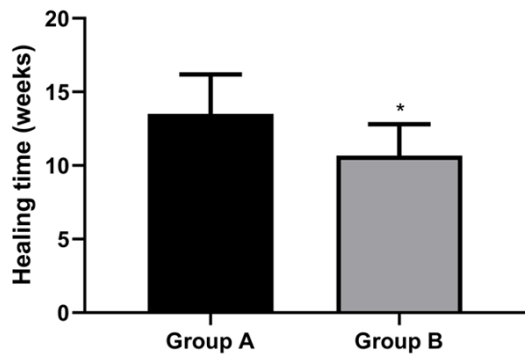


Figure 3. Comparison of healing time. The healing time was significantly shorter in Group B ($P < 0.05$). Note: * indicates $P < 0.05$ when compared with Group A.

Group A and (90.13 \pm 4.83) points in Group B. The quality of life score was (83.82 \pm 5.23) points in Group A and (94.29 \pm 3.43) points in Group B. The quality of life scores were higher in Group B ($P < 0.05$). See **Table 5** for details.

Discussion

With the rapid development of the industrial age, the incidence of fractures has also increased. Fractures are commonly treated by fixation, whose results are usually favorable, but sometimes there is fixation failure and non-healing. Plate fixation leads to hard lump protrusions and soft tissue adhesion, thus resulting in limited rotation, loss of fixation, and pain [13]. Therefore, it is necessary to find safer and less invasive therapeutic methods for fractures. In our study, patients treated with ESIN had better operative conditions. As reported by

a similar study, minimally invasive titanium elastic nail fixation has the advantages of less damage, faster recovery, and no skin scarring formation [14]. This indicates that patients treated with ESIN have a small incision and short hospitalization time. We also compared the knee function recovery between Groups A and B, and found that the KROM and the excellent rate of knee function recovery were better in Group B. Another similar study has shown that ESIN fixation for displaced clavicle fracture in children leads to less trauma, slighter influence on skin, and fewer complications, and that the children treated with this method have faster fracture healing and better postoperative functional recovery [15]. This suggests that the application of ESIN to tibial fracture can make functional recovery and operative conditions better.

As a pleiotropic cytokine that exerts a central function in the comprehensive immune defense network against infections, IL-6 functions through classical or anti-signaling pathways, which has different effects on immune capacity [16]. Each member of the IL-6 family triggers essential responses to the physiological control of immune homeostasis, hematopoiesis, inflammation, development, and metabolism [17]. Generally, when homeostasis is dysregulated by infections or tissue damage, IL-6 will be produced immediately, and will then help the host by activating acute phase and immune responses. However, this excessive and continuously synthesized cytokine has a pathological effect on acute systemic inflammatory response syndrome and chronic immune-mediated diseases, respectively [18]. TNF- α is also a pleiotropic cytokine and functions *in vivo* to balance immunity and inflammation. In addition to defending pathogens and facilitating inflammation resolution and tissue regeneration, it has the pathogenicity of triggering inflammation, stimulating the vascular endothelium, and damaging tissues [19]. Moreover, this cytokine has direct catabolism on skeletal muscles and causes muscle wasting via inducing the ubiquitin-proteasome system [20]. In our study, postoperative IL-6 and TNF- α levels were lower in Group B. According to a previous study, delayed healing and bone nonunion are partly caused by compound inflammation-induced local inflammation, because inflammation is the main factor that determines muscu-

Application of ESIN in tibial fracture

Table 3. Comparison of postoperative adverse reactions [n (%)]

| Categories | Group A (n=57) | Group B (n=43) | χ^2 value | P value |
|--|----------------|----------------|----------------|---------|
| Wound infection | 2 (3.51) | 1 (2.33) | - | - |
| Fracture re-displacement | 1 (1.75) | 1 (2.33) | - | - |
| Recent joint stiffness | 4 (7.02) | 2 (4.65) | - | - |
| Decrease in local density of affected limb | 1 (1.75) | 1 (2.33) | - | - |
| Delayed healing | 2 (3.51) | 1 (2.33) | - | - |
| Muscular atrophy | 2 (3.51) | 0 (0.00) | - | - |
| Angulation deformity | 3 (5.26) | 0 (0.00) | - | - |
| Limb length inequality | 2 (3.51) | 0 (0.00) | - | - |
| Total incidence | 17 (29.82) | 6 (13.95) | 8.295 | 0.004 |

Table 4. Comparison of excellence of knee joint function recovery [n (%)]

| Categories | Group A (n=57) | Group B (n=43) | χ^2 value | P value |
|----------------|----------------|----------------|----------------|---------|
| Excellent | 12 (21.05) | 26 (60.47) | - | - |
| Acceptable | 9 (15.79) | 10 (23.26) | - | - |
| General | 21 (36.84) | 4 (9.30) | - | - |
| Poor | 15 (26.32) | 3 (6.98) | - | - |
| Excellent rate | 21 (36.84) | 36 (83.72) | 13.231 | 0.000 |

Table 5. Comparison of postoperative quality of life ($\bar{x} \pm sd$)

| Groups | n | Physical function | Activity of daily living | Physiological function | Quality of life |
|---------|----|-------------------|--------------------------|------------------------|-----------------|
| Group A | 57 | 75.33±4.32 | 83.19±3.22 | 77.43±4.32 | 83.82±5.23 |
| Group B | 43 | 85.30±5.43 | 92.11±2.43 | 90.13±4.83 | 94.29±3.43 |
| t | | 10.230 | 15.190 | 13.830 | 11.400 |
| p | | <0.001 | <0.001 | <0.001 | <0.001 |

loskeletal health and regeneration [21]. Therefore, we suspect that the short healing time in Group B, which was confirmed in our research, may be related to inflammatory cytokines. There are also studies showing that minimally invasive ESIN has remarkable efficacy and rapid postoperative recovery, conducive to fracture healing [22]. ESIN can restore the jog stress at the fracture end, promote fracture healing, and maintain the integrity of fracture hematoma and blood supply, as well as accelerate healing; thus accelerating bone healing rate and better restoring bone length [23]. This reveals that ESIN is beneficial to bone healing. We also found that this treatment caused fewer adverse reactions than plate fixation. ESIN fixation is simple, reliable, and minimally invasive in the treatment of children with femoral neck fracture, and it can restore functional activity as soon as possible and reduce complications

[24, 25]. This may be because elasticity limits the amount of permanent deformation of the nail during insertion, and promotes callus formation via limiting stress. Moreover, in addition to acting as an internal splint and maintaining the length and alignment, elastic nails can be moved rapidly, allowing sufficient movement of the fracture site in order to form a callus, and reduce potential risks of osteonecrosis, bodily injury, and re-fracture [26]. Finally, we found that the patients treated with ESIN had higher quality of life.

There are still shortcomings in this study. We have not observed the final prognosis of the patients and not found the most suitable intramedullary nail materials, so we will continue to conduct research and to update this study.

To sum up, patients treated with ESIN have a better curative effect, faster recovery, and fewer adverse reactions compared with plate fixation.

Disclosure of conflict of interest

None.

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Application of ESIN in tibial fracture

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