ORIGINAL RESEARCH

# Effect of Internal Fixation of Tibial Fracture with Suprapatellar Approach and Subpatellar Approach on Fracture Union and Knee Function Recovery

Yanglin Gu, PhD; Guangchang Wang, MD; Jia Han, MD; Lin Gan, MD


## ABSTRACT

**Background** • The tibia is one of the most vulnerable bones in the human body, accounting for 13.7% of the total fractures. Most tibial fractures (distal articular surface) are caused by high-violence trauma. In recent years, with the rapid development of China's industry, the incidence of tibial fractures has shown an increasing trend.

**Aim** • To investigate the effect of internal fixation of tibial fractures per suprapatellar approach on fracture union and knee function recovery.

**Methods** • A total of 100 patients with tibial shaft fractures who underwent operations in our hospital were selected as the subjects. They were divided into a suprapatellar group (suprapatellar approach for intramedullary nail fixation) and a subpatellar group (subpatellar approach for intramedullary nail fixation) according to a prospective randomized study, with 50 cases in each group. The operative time, blood loss, X-ray irradiation times, fracture healing time, postoperative knee pain score, knee Lysholm score, and surgical complication rate were compared between the two groups.

**Results** • There were no significant differences in operative time, blood loss, and fracture healing time between the suprapatellar and subpatellar groups ($P > .05$). The number of X-ray irradiations needed and visual analog scale (VAS) scores were lower in the suprapatellar group than those in the subpatellar group ($P < .05$). The Lysholm score was used to evaluate knee function 6 months postoperatively, and swelling and pain scores were higher in the subpatellar group than in the suprapatellar group ($P < .05$). However, there were no significant differences in the knee Lysholm total score between the two groups ($P > .05$). There were also no significant differences in postoperative complications between the two groups ($P > .05$).

**Conclusion** • Suprapatellar intramedullary nailing reduced the number of intraoperative X-ray irradiations. Postoperative knee joint pain caused by intramedullary nailing was less, which was beneficial to the early functional knee joint exercise. (*Altern Ther Health Med.* [E-pub ahead of print.])


**Yanglin Gu**, PhD; **Lin Gan**, MD, Department of Orthopedics; Jiangnan University Medical Center; Wuxi; Jiangsu; P.R. China. **Guangchang Wang**, MD; **Jia Han**, MD, Department of Orthopedics; The Affiliated Wuxi No. 2 People's Hospital of Nanjing Medical University; Wuxi; Jiangsu; China.

*Corresponding author: Lin Gan, MD*
*E-mail: wxeygyl@163.com*

## INTRODUCTION

The tibia has walking and weight functions for the human body. A tibial fracture is one of the most common types because its position is relatively low and has minimal soft-tissue coverage. Therefore, the tibia is vulnerable, accounting for 13.7% of the fractures that occur in the body. Violence is the most common cause of open fractures.[1] The intramedullary fixation system has been the preferred method for the treatment of tibial fracture because of its minimally invasive axial fixation and low reoperation rate. Clinically, common surgical techniques include suprapatellar and subpatellar approaches. The subpatellar approach is prone to a secondary displacement of fracture ends due to the placement of nails in the knee flexion position, while the suprapatellar approach has a short operation time and a low incidence of postoperative knee pain. However, some scholars believe that the suprapatellar approach easily damages the quadriceps femoris muscle and the parapatellar supporting ligament; therefore, different clinical opinions have been presented on choosing this approach.[2] Therefore, this study aims to compare the effects of two surgical approaches in patients with tibial fractures to provide guidance and a basis for future clinical practice.

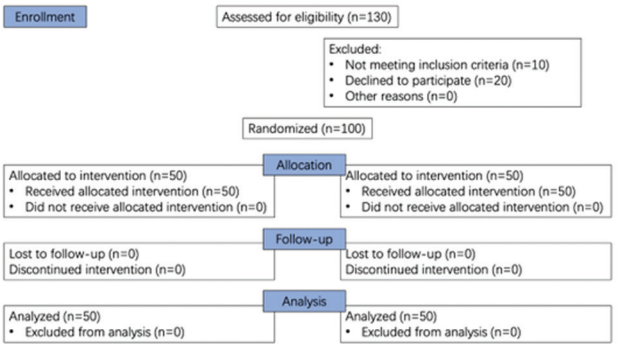
## MATERIALS AND METHODS

### Patient selection

The study included 100 patients with tibial shaft fractures who underwent operations in our hospital from April 2016 to March 2019. We divided them into the suprapatellar group (suprapatellar approach for intramedullary nail fixation) and

subpatellar group (subpatellar approach for intramedullary nail fixation) according to a prospective randomized study design, with each group having 50 cases. The inclusion criteria were as follows: tibial fracture of the lower limb due to trauma; physical examination after admission revealed pain, swelling, malformation, and dysfunction of the lower limb confirmed by X-ray and CT examination; those aged 19–65 years; AO-OTA classification type A or B; surgical treatment performed within 2 weeks after fracture; met the requirements of the Medical Ethics Committee. We excluded those with: fractures due to disease (malignant bone tumor, bone tuberculosis, and severe osteoporosis), coagulation disorders, serious vascular and nerve injury, large soft-tissue defect, or severe wound contamination, old fracture, and previous neurological dysfunction of the lower limbs and muscle atrophy.

**Figure 1.** The CONSORT Flow Diagram of Patients Included in this investigation




### Patient eligibility

In the suprapatellar group, we included those aged 19–58 years, with an average age of 44.3 ± 8.5 years, composed of 31 men and 19 women. The interval from fracture to operation was 4.0 ± 1.2 days. Among them, 30 patients had left-sided tibial fractures and 20 on the right. 20 cases had AO-OT type A fracture while 30 cases were with type B. In addition, hypertension was reported in nine patients, and one had diabetes.

In the subpatellar group, we included those aged 20–65 years, with an average age of 46.1 ± 7.8 years. This group was composed of 27 men and 23 women. The interval from fracture to operation was 3.8 ± 1.5 days. Among them, 26 patients had a left-sided tibial fracture while 24 had a fracture on the right side. AO-OT type A was reported in 23 cases and 27 cases had type B fractures. In addition, five patients had hypertension, and two had diabetes. There were no significant differences in baseline data between the two groups ($P > .05$).

### Operation method

The suprapatellar approach was used for intramedullary nail fixation. After induction of general anesthesia, the patient was positioned supine, and a long pillow was placed behind the femoral head to maintain flexion. Next, an airbag niquet was placed at the thigh root of the affected limb, and the surgical area was disinfected. The knee joint of the affected limb was flexed at 5 – 10°. Then, a longitudinal incision of 4 cm was made in the middle of the suprapatellar. The quadriceps tendon was sharply separated into the suprapatellar bursa. Navigation and protective sleeves were then inserted through the incision from the rear of the patella to the proximal tibia; the insertion point was located on the medial side of the lateral tibial spine during anterior-posterior fluoroscopy and next to the front of the joint during lateral fluoroscopy. Consequently, intramedullary nails were inserted after non-rotation and angular displacement under C-arm fluoroscopy. Two screws were then placed in the distal and proximal holes for interlocking fixation. Finally, nail tail nuts were installed after compression fracture, and normal saline was used to rinse and for easier layer-by-layer sutures.

The subpatellar approach was used for internal fixation with an intramedullary nail. In the same group as the suprapatellar group, the knee joint was in extreme flexion, and an incision of 5 cm was made from the lower edge of the patella to the tibial tuberosity. A longitudinal incision was made at the medial edge of the patellar tendon, and a needle was then inserted into the pulp cavity corresponding to the highest point of the tibia after exposure. After reduction, the pulp was expanded. Next, a fracture reductor was inserted under the guidance of the C-arm, and intramedullary nails were inserted along the guide needle to lock the two distal screws. Finally, nail tail nuts were installed after compression fracture, and normal saline was used to rinse for easier layer-by-layer sutures.

### Observation indexes

The operative time, blood loss, X-ray irradiation times, and fracture healing time, along with postoperative knee pain score using the VAS, on the first, third, seventh, and 14$^{th}$ days were noted. The higher the score, the more severe the pain. VAS score, knee Lysholm score, and postoperative complication rate were compared between the two groups.

We used the Lysholm score to assess the knee-specific symptoms. The total scores for each are as follows: limping, 5; support, 5; joint interlocking, 15; instability, 25; swelling, 10; stair climbing, 10; squatting, 5; and pain, 25. The higher the score, the better the knee function.

### Treatment outcome and statistical analysis

SPSS software (version 21.0) was used for statistical analysis. Surgical time, blood loss, fracture healing time, and other measurement data of the two groups were expressed as $x \pm s$. $t$ test was used for comparison between groups, and the $\chi^2$ test was used for comparison of counting data such as complication rate. Statistical significance was set at $P < .05$.

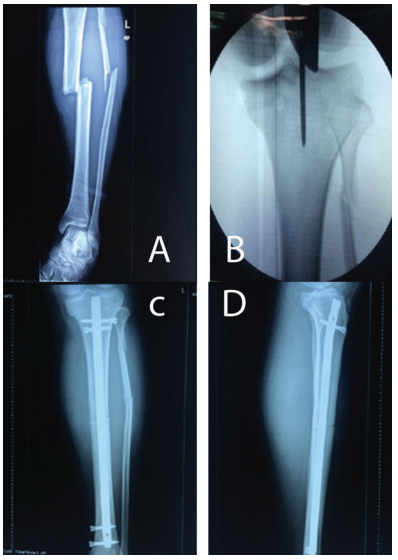
The CONSORT flow diagram of patients included in this investigation is presented in Figure 1.

## RESULTS

### Comparison of operation conditions between the two groups

There were no significant differences in operative time, blood loss, and fracture healing time between the suprapatellar and subpatellar groups ($P > .05$). X-ray irradiation times in

**Figure 2.** A 45-Year-Old Male Patient had Left Tibiofibular Fracture Caused by a Traffic Accident. (A) Anteroposterior X-ray of the Patient at Admission; (B) Intraoperative X-ray of the Patient Treated with Intramedullary Nail via Suprapatellar Approach; (C, D) Postoperative Review X-ray Which Showed a Good Reduction Effect and Stable Internal Fixation. C was anteroposterior X-ray, and D was lateral X-ray.




the suprapatellar group were lower than those in the subpatellar group ($P < .05$) as shown in Table 1.

VAS scores were compared 1 to 14d after the operation, and the suprapatellar group had lower VAS scores than the subpatellar group ($P < .05$), as shown in Table 2.

The Lysholm score was used to evaluate knee function 6 months postoperatively; swelling and pain scores were higher in the suprapatellar group than in the suprapatellar group ($P < .05$). However, there were no significant differences in the knee Lysholm total score between the two groups ($P > .05$) as shown in Table 3.

### Comparison of postoperative complications between the two groups

After the operation, there were no significant differences in postoperative complications between the two groups ($P > .05$) as shown in Table 4.

## DISCUSSION

Tibial fracture treatment aims to restore the length of the tibia and ensure its line of force to maintain the maximum stability of the knee joint. However, because of the relatively large medullary cavity of the distal tibia, it is difficult to reduce; thus, a high risk for unstable fixation or malunion exists. In addition, the minimal soft tissue around the fracture cannot provide a good environment for fracture healing, which will also cause difficulties in fracture repair and maintenance of fixation.[3,4,5] Physiological studies have found that the tibia is the main bone in the lower leg bone. The upper end forms the knee joint with the patella through the tibial plateau and the lower end of the femur, and the

**Figure 3.** A 62-Year-Old Male Patient had Left Tibiofibular Fracture Caused by a Traffic Accident. (A) Patient's Upright X-ray at Admission; (B) Surgical Procedure; (C, D) Postoperative Follow-Up X-ray, Which Showed a Good Reduction Effect and Stable Internal Fixation.

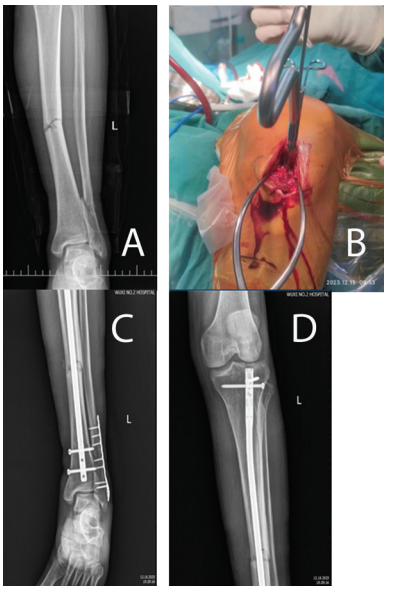



**Table 1.** Comparison of Operation Conditions Between the Two Groups ($x \pm s$)

| Groups | suprapatellar group | subpatellar group | *t* value | *P* value |
|---|---|---|---|---|
| n | 50 | 50 | | |
| operative time (min) | 91.31 ± 9.84 | 93.01 ± 8.77 | -0.912 | .364 |
| blood loss (mL) | 102.3 ± 18.5 | 99.6 ± 19.0 | 0.720 | .473 |
| X-ray irradiation times (times) | 14.8 ± 2.6 | 17.0 ± 3.3 | -3.703 | .000 |
| fracture healing time (weeks) | 12.6 ± 1.1 | 12.8 ± 1.3 | -0.830 | .408 |

**Table 2.** Comparison of Knee Pain Degree Between the Two Groups After Operation ($x \pm s$, Points)

| Groups | suprapatellar group | subpatellar group | *t* value | *P* value |
|---|---|---|---|---|
| n | 50 | 50 | | |
| Postoperative 1 d | 3.31 ± 0.94 | 3.89 ± 0.89 | -3.168 | .002 |
| Postoperative 3d | 3.01 ± 0.80 | 3.61 ± 0.85 | -3.635 | .000 |
| Postoperative 7d | 2.61 ± 0.74 | 3.02 ± 0.78 | -2.696 | .008 |
| Postoperative 14d | 2.20 ± 0.70 | 2.56 ± 0.76 | -2.464 | .015 |

**Table 3.** Comparison of Knee Function Scores Between the Two Groups After the Operation ($x \pm s$, Points)

| Groups | suprapatellar group | subpatellar group | *t* value | *P*-value |
|---|---|---|---|---|
| n | 50 | 50 | | |
| claddiness | 4.09 ± 0.62 | 3.95 ± 0.66 | 1.093 | .277 |
| support | 4.03 ± 0.71 | 4.14 ± 0.66 | -0.802 | .424 |
| Joint interlocking | 13.14 ± 1.42 | 12.71 ± 1.80 | 1.326 | .188 |
| instability | 22.30 ± 2.03 | 21.63 ± 1.95 | 1.683 | .096 |
| swelling | 8.71 ± 0.74 | 8.36 ± 0.80 | 2.271 | .025 |
| upstairs | 8.03 ± 0.95 | 8.23 ± 0.81 | -1.133 | .26 |
| squatting | 3.84 ± 0.82 | 3.69 ± 0.76 | 0.949 | .345 |
| pain | 22.71 ± 2.00 | 21.13 ± 2.31 | 3.656 | .000 |
| total score | 86.85 ± 7.39 | 84.01 ± 9.20 | 1.702 | .092 |

**Table 4.** Comparison of Operation Complications Between the Two Groups

| Groups | suprapatellar group | subpatellar group | $\chi^2$ value | *P* value |
|---|---|---|---|---|
| n | 50 | 50 | | |
| The intramedullary nail is loose | 50 | 50 | | |
| Soft tissue infection | 1 | 2 | | |
| Delayed union | 0 | 1 | | |
| Complication rate (%) | 1 | 1 | 0.709 | .400 |

lower end forms the ankle joint with the distal end of the fibula. Under normal physiological conditions, the tibia is angled forward and outward. Once a fracture occurs, traumatic knee arthritis and ankle arthritis occur, delaying the fracture healing process.[6]

At present, there are two main clinical methods for tibial fractures: conservative treatment and surgical treatment. Although conservative treatment can obtain a certain therapeutic effect, patients cannot tolerate staying in bed for a long time with joint immobilization, as well as several postoperative complications; therefore, the vast majority of patients mainly choose surgical treatment.[7]

In recent years, with the continuous update of clinical treatment plans and concepts, the treatment concept of distal tibia fractures has also changed. It is necessary to achieve reduction and fixation of fracture and obtain a more stable fixation effect according to different conditions of fracture and different degrees of trauma.[8] Furthermore, reduction techniques or careful surgical treatment should be used as much as possible to protect the patient's soft tissue and bone blood supply while providing a certain basis for early safe activities and rehabilitation of patients. Therefore, choosing a reasonable surgical method is of great significance for improving the prognosis of patients.[9]

Intramedullary nail fixation has always been the gold standard for the treatment of tibial shaft fractures, which can ensure the stability and blood flow of the fracture end. During the treatment process, it does not need to strip the surrounding soft tissue around the fracture dissection and does not affect the periosteal blood supply, to preserve the hematoma of the fracture. Limited dissection, even when necessary, is minimal and minimizes the destruction of the blood supply around the fractured end.[10]

At present, there are controversies regarding the choice of surgical approach. The subpatellar approach is simple and generally operated under direct vision, with little trauma. However, some scholars have pointed out that patients with the subpatellar approach need to perform fracture reduction under knee flexion, and the anterior angle of the fracture end will increase by >10° in the process of patellar tendon traction. Therefore, it is difficult to reduce the fracture, involving several times reduction during the operation, and nail placement with multi-segmental and concomitant fractures. In this approach, soft tissue injury can be aggravated, and continuous X-ray examination is required to confirm.[11-13] Studies have also found that the strength of the quadriceps femoris muscle decreases after the subpatellar approach, and the proliferation of callus formation at the entrance of the intramedullary nail would cause friction and aggravate the knee joint pain, affecting the prognosis of the patients.[14,15]

The other surgical approach is the suprapatellar approach, which adopts the extension position operation, and is convenient for fracture reduction and fixation of multi-segment fracture and proximal fracture of the tibial shaft, the traction of the patellar tendon is slight, and the treatment of the tibial shaft fracture with intramedullary nail technique is satisfactory when necessary.[16,17] Moreover, the suprapatellar approach does not damage the patellar ligament and avoids the anterior saphenous patellar nerve during the operation. Therefore, the incidence of postoperative complications is low. The slight traction of the patellar ligament during the operation helps to protect the integrity of the patellar ligament and the soft tissue under the patellar ligament, thus reducing the incidence of postoperative knee pain and other complications.[18-20]

In this study, the number of X-ray irradiations in the suprapatellar group was less than that in the subpatellar group, suggesting that the suprapatellar approach for tibial fracture can reduce the number of X-ray irradiations in patients. The VAS scores of the subpatellar group were lower than those of the suprapatellar group at 1d to 14d after the operation, suggesting that the suprapatellar approach for tibial fracture helps relieve pain in 6 months postoperatively. The knee joint Lysholm score was used to evaluate knee joint function, and the results showed that the swelling and pain scores in the suprapatellar group were higher than those in the subpatellar group, but there was no statistical difference in the knee joint total Lysholm score between the two groups, indicating that in the treatment of pain and swelling reduction in patients with tibial fractures, the suprapatellar approach has an obvious advantage compared to the subpatellar approach. There was no statistical difference in surgical complication rates between the suprapatellar group and the subpatellar group, suggesting that the two surgical approaches may not have any effect on postoperative complications.

The findings of the study suggest that closed reduction of the intramedullary nail is a common clinical treatment method for tibial shaft fracture and is one of the gold standards for the treatment of tibial shaft fracture. The selection of the suprapatellar approach can avoid iatrogenic damage to the patellar ligament during surgery, reduce the incidence of postoperative knee swelling and pain, and lay a basis for the rational selection of the surgical approach.

### Limitations

This study has limitations. First, a limited number of patients were enrolled in this study. Second, the impact of the two approaches on patients was not analyzed from the perspective of molecular biology. Therefore, further analysis of larger sample size and long-term follow-up are needed for future research.

## CONCLUSION

Compared to the subpatellar approach, suprapatellar intramedullary nailing in the treatment of tibial fracture mainly reduced the number of intraoperative X-ray irradiations and the postoperative knee joint pain caused by intramedullary nailing, which was beneficial to the early functional exercise of the knee joint of patients that affects their daily living.

## ETHICS

The study was approved by the hospital's ethics committee. Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to the treatment via written consent.

## AUTHOR DISCLOSURE STATEMENT

The authors declared that there is no conflict of interest between them.

## FUNDING

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## AUTHOR CONTRIBUTIONS

Yanglin Gu and Guangchang Wang designed the experiment; Jia Han drafted the work; Lin Gan and Yanglin Gu collected the data; Guangchang Wang and Jia Han analyzed and interpreted the data; and, Lin Gan and Yanglin Gu wrote the article.

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