

Locked META intramedullary nailing fixation for tibial fractures via a suprapatellar approach

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ABSTRACT

Background: Intramedullary nailing is an effective approach for treatment of diaphyseal tibial fractures. However, infrapatellar intramedullary nailing can easily cause angulation and rotation displacement at the fracture ends and increase risk of postoperative infection. Intramedullary nailing via the suprapatellar approach was proved with good reduction and fixation. We used locked intramedullary nailing for the treatment of tibial fractures via a suprapatellar approach in this study.

Materials and Methods: 23 patients undergoing tibial fractures fixation by locked META intramedullary nailing via a suprapatellar approach were enrolled between June 2012 and October 2013. There were 18 males and 5 females. The average age was 35.5 years (range 18-60 years). The intraoperative data including operative time and blood loss and postoperative data consisting of hospital stays, fluoroscopy time, fracture healing time and complications were all recorded.

Results: The average operative time, blood loss, fluoroscopy time and hospital stay were 78.2 ± 9.1 min, 90.4 ± 23.4 mL, 38.5 ± 6.5 s and 11 ± 3.4 days respectively. The mean followup period in all the patients was 15.5 months. Callus appeared in the patients at average 8 weeks after surgery. The mean knee and ankle range of motion were significantly improved at the last followup ($P < 0.05$). The average Hospital for Special Surgery and Olerud–Molander scores was 92 ± 4.3 points and 93.6 ± 3.9 points, respectively. No complications were observed.

Conclusion: Locked META intramedullary nail fixation via a suprapatellar approach is safe and effective for patients suffering from tibial fractures and earlier functional recovery.

Key words: Fracture fixation, META intramedullary nail, suprapatellar approach, tibial fracture

MeSH terms: Orthopaedic equipment, osteosynthesis, tibia fracture

INTRODUCTION

Tibial fractures are the most common amongst the long bone fractures in the human body,¹ and are usually caused by high-energy trauma such as road traffic accidents and falling from a height. At present, intramedullary nailing has often been the treatment of choice for the majority of diaphyseal tibial fractures²⁻⁴ because of its early rehabilitation and early weight-bearing after surgery.⁵

The management of tibial fractures by intramedullary nailing is usually accomplished via the infrapatellar approach with the knee in flexion or even hyperflexion ($120-130^\circ$) and has proven to be successful. However, when it comes to some special types of tibial fractures such as fracture of metaphysis, multisegmental fracture and associated ipsilateral multiple fractures, as well as with poor soft tissue conditions on the site of intramedullary nail insertion, hyperflexion may cause many difficulties in intraoperative closed reduction and fluoroscopic imaging and the treatment of other ipsilateral fractures and may increase risk of postoperative infection.⁶⁻⁹ Furthermore, proximal and distal tibias, which mainly consist of cancellous bone with a large medullary cavity, lack thicker cortical bone; therefore, infrapatellar intramedullary nailing can easily

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cause angulation and rotation displacement at the fracture ends due to the poor stability of inserted intramedullary nail.¹⁰

Semiflexion tibial nailing (with the knee in 10–20° flexion) via medial parapatellar approach was initially developed by Tornetta and Collins⁶ for the treatment of proximal tibial fractures. On the basis of some researchers proposed to perform intramedullary nail via the suprapatellar approach.^{11–13} Jakma *et al.* have described the method of intramedullary nailing from the suprapatellar pouch in a technical note, with the advantage of easy performance and no risk of injuries to patellar tendon and infrapatellar nerve.¹³

Furthermore, the conventional tibial intramedullary nail is designed with two proximal and distal locking screws at both sides, respectively and the most proximal and distal locking screws are both far away from the end of the intramedullary nail. During the fixation for fracture of metaphysis and multisegmental fracture, few screws and a uniplanar locking direction often aggravate the horizontal and rotation displacement of proximal and distal fractured fragments, thereby supplemental plate fixation is usually required and thus increases the surgical trauma and costs.¹⁴ In this study, a locked META intramedullary nail and the matched locking screws were used. The current study aimed to retrospectively evaluate the efficacy of intramedullary nailing via a suprapatellar approach for specific tibial fractures.

MATERIALS AND METHODS

23 patients undergoing tibial fractures fixation by locked META intramedullary nailing via a suprapatellar approach between June 2012 and October 2013 were enrolled. The inclusion criteria were: The fresh tibial fractures with the articular surface not involved; patients aged from 18 to 60 years; no underlying diseases, such as essential hypertension and heart disease. Patients who have a pathological fracture, neurovascular injuries, severe Gustilo III open fractures, or other diseases affecting lower limbs function were all excluded. This study has received ethical clearance from ethical committee of our hospital. The demographic data consisting of age, gender and clinical data including causes of fracture, type of fracture as per AO classification,¹⁵ affected sides and associated injury are noted in each patient [Table 1]. Briefly, there were 18 males and 5 females. The average age was 35.5 years (range 18–60 years). The fractures were classified as 41A2 (n=2), 41A3 (n=5), 42A2 (n=6), 42C2 (n=4) and 43A1 (n=6). Complex fractures were defined as type C2 and simple fractures were defined as

Table 1: Clinical details of patients

Parameter	Patients
Age, years (range)	35.5 (19–55)
Gender, n (%)	
Male	18 (78.3)
Female	5 (21.7)
Causes of fracture, n (%)	
Road traffic accidents	15 (65.2)
Falling from a height	5 (21.7)
Bruise caused by heavy object	3 (13.1)
AO classification, n (%)	
41A2	2 (8.7)
41A3	5 (21.7)
42A2	6 (26.1)
42C2	4 (17.34)
43A1	6 (26.1)
Patency, n (%)	
Open fracture: Gustilo I	5 (21.7)
Open fracture: Gustilo II	1 (4.4)
Closed fracture	17 (73.9)
Affected side, n (%)	
Left	10 (43.5)
Right	13 (56.5)
Associated injury, n	
Ipsilateral femoral shaft fracture	2
Infrapatellar soft tissue contusion	3
Calf extensive psoriasis	1
Ipsilateral fracture of fibula	18
Pelvic fracture	4
Fracture of lumbar vertebra	2
Barton fracture	3
Acromioclavicular dislocation	2

types A1, A2 and A3. There were 6 cases of open fracture and 17 cases of closed fracture.

All the operations were performed at average of 5.5 days (range 3–12 days) after the accidents and all the patients were treated with closed reduction and suprapatellar interlocking (IL) intramedullary nailing, of whom 12 cases also received blocking screws to improve nailing of proximal tibia fractures. A locked Trigen META intramedullary nail and the matched locking screws (Smith and Nephew, Inc., Memphis, TN, USA) were used in surgery vital procedure for each patient.

Operative procedure

All procedures were performed under the same general anesthesia. Patient with closed fractures were placed supine on a radiolucent operating table, with the affected hip in 45° flexion and affected knee in 15° flexion [Figure 1]. No tourniquet was used. The location of the anterior border of tibial tubercle and patella was marked on the skin. A 3 cm midline skin incision was made at the superior pole of the patella, followed by a deep dissection through quadriceps tendon and suprapatellar bursa. The entry



Figure 1: Preoperative clinical photograph showing the affected limb was positioned on operating towels with the hip flexed 45° and the knee flexed 15°

point for nail insertion was determined according to the skin markers using a surgeon's index finger to touch the anterior border of tibial tubercle along fossa intercondylaris femoris and the joint space behind the patella. A protective sleeve (13.5 mm in inner diameter, 14.5 mm in outside diameter) was inserted through the pathway with its conical tip down to the anterior lip of the tibia and then a 2.5 mm nonthreaded guide pin was passed within the protective sleeve. Under a C-arm fluoroscopic guidance, the entry point for the guide pin insertion was identified as the point just medial to the lateral tibial spine on the anteroposterior radiograph,¹⁶ and at the juncture of the anterior border and the ventral cortex of the tibial plateau on the lateral radiograph. The guide pin was drilled in approximately 5–6 cm but not to penetrate the posteromarginal cortex of the tibia and then a 3 mm diameter long ball guide pin was inserted. Closed reduction was performed and the long ball guide pin was slowly inserted across the fracture, with the distal guide pin located at distal metaphysis of the tibia. If the pin was excessively deviated from medullary cavity center under the C-arm fluoroscopy, it was corrected using a good finger. Once the guide pin position had been accepted, an entry reamer was introduced to expand the medullary cavity. Nail length was determined using a specially designed ruler. Intramedullary reaming was then performed 1.5 mm beyond the chosen nail diameter and the properly selected intramedullary nail was inserted. The proximal end of the intramedullary nail should be placed about 1 cm below the opening on anterior lip of the tibia and distal end should be placed at metaphyseal lines. If it was difficult to insert by hand (especially for distal tibial fractures fixation), beating the nail tail could assist the nail to reach as far as the articular surface of the distal tibia. Intramedullary nail location and fracture reduction were reconfirmed using a C-arm fluoroscopy. A blocking screw was used to facilitate reduction and correct angulation and displacement. Electromagnetic directional navigation

device (SURESHOT Distal Targeting System, Smith and Nephew, Inc., Memphis, TN, USA) was used for the implantation of distal IL screws, among which 2 screws were implanted for middle and proximal fractures of the tibia and at least 3 screws were for distal tibial fractures (2 from the medial to lateral and 1 from anterior to posterior). Proximal nail targeting device was installed for implantation of proximal IL screws: First implanted an IL screw to the power hole, if fracture separation was obvious under fluoroscopy, compression screws were used to moderately pressurize the fracture fragments and then re-implanted the remaining screws. Finally, the outer connector bar was removed and the tail cap was installed. Knee joint cavity was washed with 1500 mL saline, suprapatellar bursa was sutured, the quadriceps tendon was restored and the incision was sutured and pressure bandaged. No patients received plaster, plywood, plating and other external fixations after surgery.

As for patients with open fractures, debridement was performed for them and long leg brace was used for external fixation after their hospital admission. They were scheduled for elective operation until no evidence of wound infection. The surgical procedure was performed as was performed in closed fractures.

Postoperative treatment and rehabilitation exercises

Intravenous second-generation cephalosporin was given postoperatively for one day for patients with closed fractures and for 3–5 days for open fractures. Cold compression was applied at the fracture site for 7 days, 6 times/day, 30 min/time. Passive flexion and extension exercises of knee and ankle joints from postoperative day 1 and active flexion and extension exercises of knee and ankle joints and strength training of lower limb from postoperative day 3 were taken. After 1 week, patients were encouraged to get out of bed and get walking exercise with nonweight-bearing on the affected limb. After 6–8 weeks, they were allowed partial weight-bearing with crutches. After 12 weeks, the full weight-bearing was permitted according to the status of fracture union and full weight bearing was gradually restored.

The intraoperative data consisting of operative time and blood loss and postoperative data including hospital stays, fluoroscopy time, fracture healing time and complications were all recorded. Active range of motion (ROM) (forced dorsiflexion plus forced plantar flexion) was measured using a goniometer with the patient in a prone position and the knee flexed 90°. All the patients were followed up every 2 months after surgery until fracture healing, which was evaluated according to the anteroposterior and lateral X-rays by two surgeons who did not participate in

surgery and understand the patient's disease information. Assessment of knee joint function was made by means of the American Hospital for Special Surgery (HSS) knee score system,¹⁷ a 0–100 scale consisting of pain, function, ROM, muscle strength, flexion deformity, joint stability, varus and eversion deformity and the need for braces). The results are defined as excellent (>85 points), good (70–85), fair (60–69) and poor (<60). Assessment of ankle joint function was made by means of the Olerud–Molander ankle (OMA) scoring system,¹⁸ a 0–100 scale including pain, stiffness, swelling, stair climbing and so on. Excellent results equal 90–100 points, good 60–89, fair 30–59 and poor <29 points.

Statistical analyses

All analyses were performed using Microsoft Excel 2010 (Microsoft, Redmond, Washington, USA) and SPSS 10.0 software (SPSS Inc., Chicago, Illinois, USA). The quantitative data were presented as mean \pm standard deviation and qualitative data were expressed as a percentage of subjects. The differences between preoperative and postoperative ROM were analyzed by paired *t*-test. Statistically significant difference was set at $P < 0.05$.

RESULTS

The average operative time of the patients was 78.2 ± 9.1 min (range 65–100 min). The average blood loss was 90.4 ± 23.4 mL (range 60–150 mL). The average fluoroscopy time during surgery was 38.5 ± 6.5 s (range 30–50 s). The mean postoperative hospital stay of the patients was 11 ± 3.4 days (range 6–18 days).

During the mean followup period of 15.5 months (range 12–24 months), 21 patients received clinical and radiographic return visit. The remaining two patients, who had difficulty to review at the hospital, were followed up by telephone and questionnaire and their physical and X-rays

examinations were performed by local physician who were required to send the results to us.

The X-ray examination showed that callus appeared in all patients at average 8 weeks after surgery, with the fracture healing time of 16–26 weeks (average 20.2 ± 2.5 weeks). No complications were observed. No patients experienced loosening, or breakage of the internal fixation and no one complained of knee joint pain. No reduction loss and aggravating displacement occurred after the surgery. The angular deformity of limbs was 0–4° (average 1.6°) at the coronal view and sagittal angular deformity of limbs was 0–5° (average 2.1°) at the coronal view. The mean knee and ankle ROM were significantly improved at the last followup [$P < 0.05$, [Table 2]]. The average HSS score was 92 ± 4.3 points (range 78–98 points) at the final followup, with 18 cases considered as excellent and 5 as good. The average OMA score was 93.6 ± 3.9 points (range 85–100 points), with 19 cases considered as excellent and 4 as good. Patients with typical tibial fractures are shown in Figures 2 and 3. The extraction of nails has been performed for 11 patients, 6 from a suprapatellar incision under a C-arm fluoroscopic guidance and 5 from the infrapatellar conventional approach. Now cooperative study with Smith and Nephew Company on the instruments used in the extraction of nails via suprapatellar approach are in the process.

DISCUSSION

The biggest advantage of the suprapatellar approach was the extension of the knee during operation, which was

Table 2: The pre and postoperative knee and ankle ROM

Parameters	Preoperative	Postoperative	P
Knee ROM	26.74 \pm 10.72	117.91 \pm 5.31	<0.001
Ankle ROM	34.70 \pm 10.42	57.17 \pm 9.36	<0.001

The differences between preoperative and postoperative ROM were analyzed by paired *t*-test. Statistically significant difference was set at $P < 0.05$. ROM=Range of motion

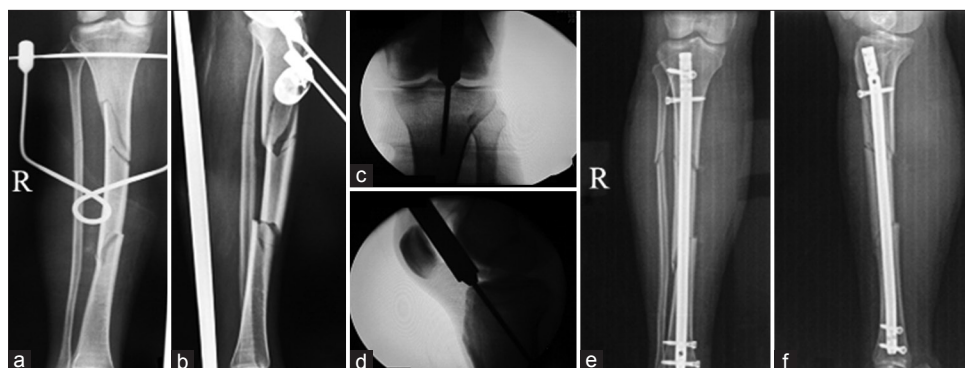


Figure 2: A 28-year-old female patient suffering tibial fracture due to falling from a height: Preoperative anteroposterior (a) and lateral (b) X-ray showing multisegmental tibial fracture in the right tibia; the entry point of the guide pin at the anteroposterior (c) and lateral position (d) under a C-arm fluoroscopy during the intramedullary nailing fixation; and anteroposterior (e) and lateral (f) X-ray at postoperative 1-week showing nail *in situ*



Figure 3: A 35-year-old male patient suffering from tibial fracture due to traffic accident preoperative (a) anteroposterior and (b) lateral computed tomography scan showing fracture in the right proximal tibia (c) postoperative anteroposterior and (d) lateral X-rays after locked tibia META intramedullary nailing via a suprapatellar approach with blocking screws (e) anteroposterior and (f) lateral x-rays showing union of fracture at 18 weeks followup (g and h) postoperative clinical photographs at 1 month showing flexion and extension of the knee

very useful in the treatment for complex metaphyseal and diaphyseal tibial fractures. In this study, all the 13 patients with tibial fractures of metaphysis, 4 cases of tibial multisegmental fractures and 2 cases of ipsilateral femoral fractures obtained satisfactory reduction and good recovery outcomes, with no loss of reduction and aggravating displacement in the followup, except for 1 case of proximal tibial fractures with 5° angulation at the sagittal view after surgery (data not shown). These acceptable results could be attributed to the nearly extend position during suprapatellar technique, since it would reduce the stretch force on patellar ligament during the reduction of proximal tibial fractures when compared with hyperflexion; as to distal tibial fractures, moderately dragging ankle joint could achieve guide pin insertion, medullary cavity expansion and nail implantation; it would be easy to observe and measure the rotation and angulation with the affected limb in extent position. Besides the application of a C-arm fluoroscopic machine combined with blocking screws,¹⁹ also facilitate fracture reduction and fixation during surgery.

Patients who received the conventional infrapatellar intramedullary nailing often felt postoperative pain,

which was related to surgery method, patellar ligament and infrapatellar nerve injury, muscle strength changes, protrusion of inserted objects tail and other factors.^{20,21} Fortunately, Gelbke *et al.*²² (2010) found that the mean contact force on the patellar articular surface was 3.83 MPa via a suprapatellar approach, lower than 4.5 MPa (a critical pressure to cause chondrocyte injury) and hence, they considered suprapatellar nailing had a limited damage to cartilage. Gaines *et al.* also proved that the suprapatellar approach was associated with a lower overall incidence of damage to intraarticular structures.²³ In this study, there was also no patient suffering from the postoperative knee pain at present, which could be explained by several reasons: First, the sleeve adjoined tightly to tibial spine and protect patella cartilage from the damage of surgical instruments; Second, the electromagnetic directional navigation and proximal nail targeting devices could conduce the insertion of screws during intramedullary nailing, not only reducing X-ray radiant exposure for the physicians and patients, but also effectively shortening the operation time and reducing complications associated with nail.²⁴ Jakma *et al.*¹³ checked the effect of suprapatellar intramedullary nailing for seven patients with tibia proximal fracture

using arthroscopy and observed partial cartilage injury in femoral trochlear, but no patient complained of knee joint pain after surgery. Hence in this study, the absence of knee joint pain was not taken as evidence of no articular cartilage injury and further research was necessary to investigate the status of articular cartilage after suprapatellar intramedullary nailing. Despite the possible risk of damage to the articular surface,²⁵ however, with the development of related protective sleeve, recent studies have shown that intramedullary nailing fixation via a suprapatellar approach was safe with many advantages.^{16,26} Sanders *et al.* (2014) have initially reported the clinical and radiographic results of tibial fractures after suprapatellar intramedullary nailing and found excellent tibial alignment, union and knee joint ROM.¹² Besides, Tyllianakis *et al.* (2000) have reported that IL intramedullary nailing for tibial fractures was a reliable method, characterized with the high rates of union and low rates of postoperative complications.²⁷ In accordance with the previous research, it was also found in our study that patients showed excellent clinical outcomes in bone union, knee joint ROM and the functional recovery, with no complications such as pain, infection, osteomyelitis and nonunion observed. It was partially due to the application of the protective sleeve in our study. However, a recent study reported the complications related to META tibial nail end cap, including the bent screw and the incomplete insertion of end cap.²⁸ In contrast, the above complications were not found in our study when treating tibial fractures with locked META intramedullary nail. The possible reason may be due to the application of electromagnetic directional navigation device during operation in our study.

Several limitations in our study must be addressed. First, as the study was not prospective and randomized, neither comparison between Trigen nail with standard intramedullary nail nor comparison between suprapatellar and infrapatellar approaches were not included. Second, the number of the cases included in the study and followup period was small. Third, the status of cartilage over patella and trochlea postsurgery has not been evaluated. Thus, further prospective studies with large population and long followup time were required to compare the clinical outcomes of tibial fractures after locked intramedullary nailing via suprapatellar and infrapatellar approaches.

CONCLUSION

Locked META intramedullary nailing via suprapatellar approach might be an efficient and convenient treatment for select tibial fractures, with less postoperative knee joint pain, fewer postoperative complications and early functional recovery.

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Conflicts of interest

There are no conflicts of interest.

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