Insert Nails When Flexing the Knee in the Femoral Fracture External Fixation: A Technical Report

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Abstract

Background: The application of external femoral fixation techniques often causes complications of knee flexion dysfunction. We report on technical modifications in the complications of external femoral fixation leading to knee flexion disorders.

Methods: We flexed the knee joint 90 degrees during the operation, and then placed the external fixation nail. A retrospective review was performed for all patients undergoing repair by this technique.

Results: A total of 52 children with femoral shaft fractures were included, the flexion of the knee joint measured at the time of discharge was 80 degrees (70-90 degrees) on average; when the external fixation is removed, the knee flexion can reach an average of 95 degrees (90-115 degrees), no children have stiff knees.

Conclusion: This technique is simple and easy to implement, and it is worthy of popularization and application in clinical practice.

Background

External fixators are widely used in orthopedic trauma and orthopedics and have become a significant method for treating fractures, severe limb injuries, osteomyelitis, bone defects, and functional reconstruction[1-3]. Femoral external fixators are commonly used for femoral lengthening, open femoral fractures, femoral bone defects, and bone reconstruction after resection of femoral tumors[4]. Compared with internal fixation, external fixation is more prone to complications such as needle tract infection, re-bone fracture, delayed healing, or joint stiffness. However, the femoral external fixator is still irreplaceable in open fractures, long oblique fractures, and multiple femoral fractures. Many complications can occur with external fixators, such as pin site infections and even bone infections [5], osteoporosis leads to loosening or prolapse of the fixed needle, and the osteotomy is healed ahead of time [6, 7]. Besides, knee stiffness is also an essential complication of external femoral fixation.

Stiffness of the knee extension can occur during the use of the femoral ring external fixator or a unilateral external fixator. Especially femoral prolongation requires long-term use of external femoral fixation, and it is more likely to cause knee stiffness. Guidera [8] et al. reported that a decreased range of motion of the knee joint occurred when the external fixator was used to extend the femur. Among them, 2 cases had a decreased knee joint motion of greater than 30° (loss ≥ 30°). Herzenberg [9] et al. reported that the knee joint mobility decreased during the femoral extension using the ring-shaped external fixator. Finally, after the external fixator was removed, the average value of the patient's activity also decreased. In 2 patients, knee mobility was lost by more than 15%. Knee stiffness is also often occur after femoral fractures with external fixation. Dabezies et al. reported 9 cases(45%) of decreased range of motion of knee after external fixation of femoral fractures, an average loss of flexion of 50 degrees [10]. Murphy et al. reported that 44% of patients have a decreased range of motion of the knee joint, which flexes less than 90°[11]. Zlowodzki et al. Reported 23 cases, the knee flexion was decreased significantly, with less than 60°[12].

We consider that the stiffness of the knee joint is related to the fixation of the iliac tibia bundle by the nail. This study explores how to reduce the occurrence of knee stiffness complications and discusses the mechanism by improving the femoral external fixation method.

Methods

Between January 2011 and June 2014, we collected all children who were operatively treated with external fixation for a femoral diaphyseal fracture at our Department of Children's Hospital of Chongqing Medical University. Inclusion criteria: 1) younger than 18 years old, 2) unilateral or double Lateral femoral shaft fracture, 3) Treatment with external fixation; exclusion criteria: 1) abnormal knee flexion and extension before surgery, 2) fracture involving the knee, 3) combined use of internal fixation and external fixation;

The X-ray of the patient admitted to the hospital showed a fracture of the femoral shaft. It was not suitable for open reduction and internal fixation, so external fixation treatment was performed. The range of motion of knee flexion and extension before surgery was normal. Closed fractures under anesthesia are reduced by lower limb traction and manual reduction, then C-arm X-ray fluoroscopy was used to confirm that the fracture alignment was proper. Open fractures were directly reduced after debridement. Then cut approximately 1cm of skin at the proximal end of the fracture, the distal end, and the bone fragment; bluntly separate the subcutaneous tissue to the bone surface. Flex the knee of the affected limb 90 degrees, then insert the external fixation nail with a diameter of 5 mm to the vertical bone surface(Figure 1). Correct the displacement of the fracture under X-ray fluoroscopy again. After confirming that the external fixing nail position is proper, install the external fixator and tighten the fixing bolt. The knee joint can be frequently flexed and extended after the external fixator is installed.

Three days after the operation, active and passive functional exercises of the affected limbs were performed, and measuring the knee flexion and extension range of motion. The patient was discharged about 1-2 weeks after the operation. The range of motion of knee flexion and extension was measured—outpatient follow-up at 1, 3, and 6 weeks after discharge, and then monthly follow-up. Follow up the range of motion of the knee joint, nail tract infection, and recurrence of fracture; X-ray observation of fracture healing, delayed healing, and non-union.

Result

A total of 52 children with femoral shaft fractures were included, including 38 males and 14 females, with an average age of 7.5 years (3.5 years to 14.6 months). There were 28 cases of open fractures, 15 cases of long oblique fractures, 7 cases of severely comminuted fractures, and 2 cases of failure of femoral traction. The average hospitalization period was 10 (range 7–14) days. The average follow-up period was 12 (range 10–24)months. Under anesthesia, unilateral external fixation was used to fix fractures. After anesthesia, the child's knee flexion can reach an average of 100 degrees (80 degrees to 125 degrees), and there is no restriction on the extension. During surgery, the knee joint can reach an average of 90 degrees

(80 to 100 degrees) after external fixation. The knee joint was actively and passively moved three days after surgery, and the flexion of the knee joint measured at the time of discharge was 80 degrees (70-90 degrees) on average; the extension was not limited(Figure 2). An X-ray confirmed that the fracture was healed entirely and removed the external fixator, external fixators were removed on an average of 16 (range 12–20) weeks. When the external fixation is removed, the knee flexion can reach an average of 95 degrees (90-115 degrees). The usual range of motion can be restored entirely within two weeks after the external fixation is removed. The remaining complications included seven patients with nail tract infections, controlled after dressing change, and antibiotic treatment; no deep infections occurred; no further fractures occurred, and no delayed or non-union fractures occurred.

Discussion

External fixators are widely used in various fields of orthopedics. Femoral external fixators are often used to correct shortened femoral deformities, femoral fractures, and reconstruction of femoral tumors. The use of femoral external fixators has a high probability of reduced knee joint mobility and knee joint stiffness, especially the use of ring-shaped external fixators. The external fixator will fix the thigh muscles and aponeurosis, so that the movement of the thigh muscles of the knee joint is restricted, thereby limiting the flexion and extension of the knee joint. Reduced knee mobility can be significantly improved after removing the external fixator. However, for patients who need to use an external fixator for a long time, such as femoral prolongation, the patient's knee flexion is limited during fixation. The knee function cannot be quickly restored after the external fixator is removed [13]. Although most patients' knee mobility can be significantly improved through functional exercise or secondary surgery, it may also lead to re-bone fractures. Therefore, the complication of femoral external fixation used to reduce knee mobility is still a relatively important issue. We found in the operation that by flexing the knee joint to 90 degrees before placing the external fixator nail, the patient can flex the knee joint by an average of 80 degrees 2-3 days after surgery. Moreover, the patient's knee flexion is not limited during the post-surgery period, and it will not cause inconvenience to life. After removing the external fixator, the patient's knee function quickly returned to normal, and no knee stiffness or mobility decreased significantly.

The flexion disorder of the knee joint after the placement of the external femoral fixator is related to the lateral femoral muscles' fixation, aponeurosis, and iliac tibial bundle with nails, the main structure is the iliac tibial bundle. The iliac tibial bundle is a thickened part of the lateral fascia of the thigh. The upper end is connected to the lateral edge of the front end of the iliac bone. The lower end is connected to the lateral tibial condyle, fibula head, and knee joint capsule[14]. The iliac tibial bundle is an important organization for maintaining knee stability and knee motion and is involved in knee flexion and extension essential [15]. The iliac tibial bundle is tougher and less elastic, it cannot be moved normally and cannot be stretched elastically after being fixed by an external fixator nail. After the iliac tibial bundle fixed by an external fixator nail, due to the poor elasticity of the lower part of the iliac tibial bundle, and the distance OG’ required for knee flexion is longer than OG(figure 3), it is difficult to flex the knee joint. And the iliac tibia bundle slides up and down along the lateral femoral muscle when extending and flexing the knee, sliding up when extending the knee and sliding down when bending the knee. In addition to sliding up

and down, there is also forward and backward movement: forward when the knee is extended, and backward when the knee is bent. After the external fixation nail fixes the iliac tibial bundle, the upward and backward movement of the iliac tibial bundle is restricted, so that the knee flexion function is limited. Moreover, the child was unwilling to exercise because of pain when pulling the nailed iliac tibial bundle when flexing the knee joint. Besides, the adhesion between the fixed iliac tibial bundle and the muscle or aponeurosis aggravated the knee joint's flexion activity after surgery, so that after removing the external fixator, there was still a limited knee flexion activity. Although the method of cutting the iliac tibial bundle at the nail tract used to improve the postoperative knee joint movement, this method is very invasive, and local adhesion formation will still affect the knee joint movement. Now we fix the external fixation nail when flexing the knee joint during surgery. The lower iliac tibial bundle OG segment fixed when flexing the knee joint is longer. The longer movable segment is reserved so that the iliac tibial bundle will not restrict the flexion of the knee joint. Moreover, more space is reserved for the iliac tibial bundle to move backward and downward when flexing the knee, to avoid the limitation of the flexion activity of the knee joint after the operation.

Conclusion

In the external fixation of the femur, the external fixation nail placed in the knee flexion position can effectively improve the knee joint's flexion dysfunction, and the knee stiffness is avoided. This method is simple and easy to implement, and it is worthy of popularization and application in clinical practice.

Declarations

Ethics approval and consent to participate

The study was approved by the Medical Ethics Committee for Clinical Ethical

Review, Children’s Hospital of Chongqing Medical University. Written informed consent was obtained for the study from the parents of the patients.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analyzed during this study have been included in the published article.

Competing interests

The authors declare that they have no competing interests.

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Authors' contribution

The authors made the following contributions: JKW and ZLW designed the study; JKW, WQC, YXS and JQQ acquired the data; JKW, GUN, GY and KG analyzed the data and drafted the article; ZLW, GXN, YXS and JQQ provided technical support and conceptual advice; and JKW, XN and KC reviewed/edited the manuscript. All authors have read and approved the final manuscript.

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Figures

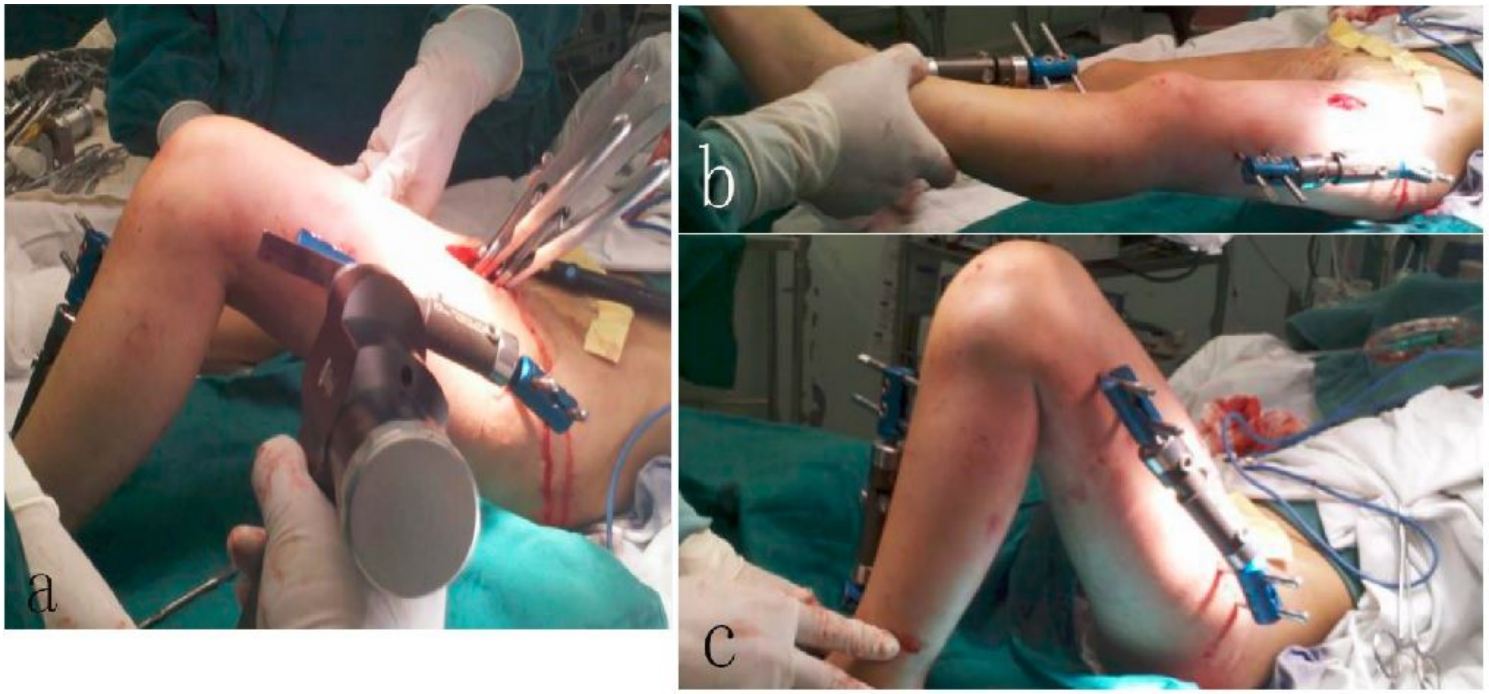

Figure 1

A eight-year-old girl, during surgery, flexes the knee of the affected limb 90 degrees and then inserts the external fixation nail(a). The knee joint can be normal flexion and extension after external fixation(b,c).

Figure 2

An eight-year-old girl whose range of motion of the child's knee joint was normal two weeks after surgery(a,b).

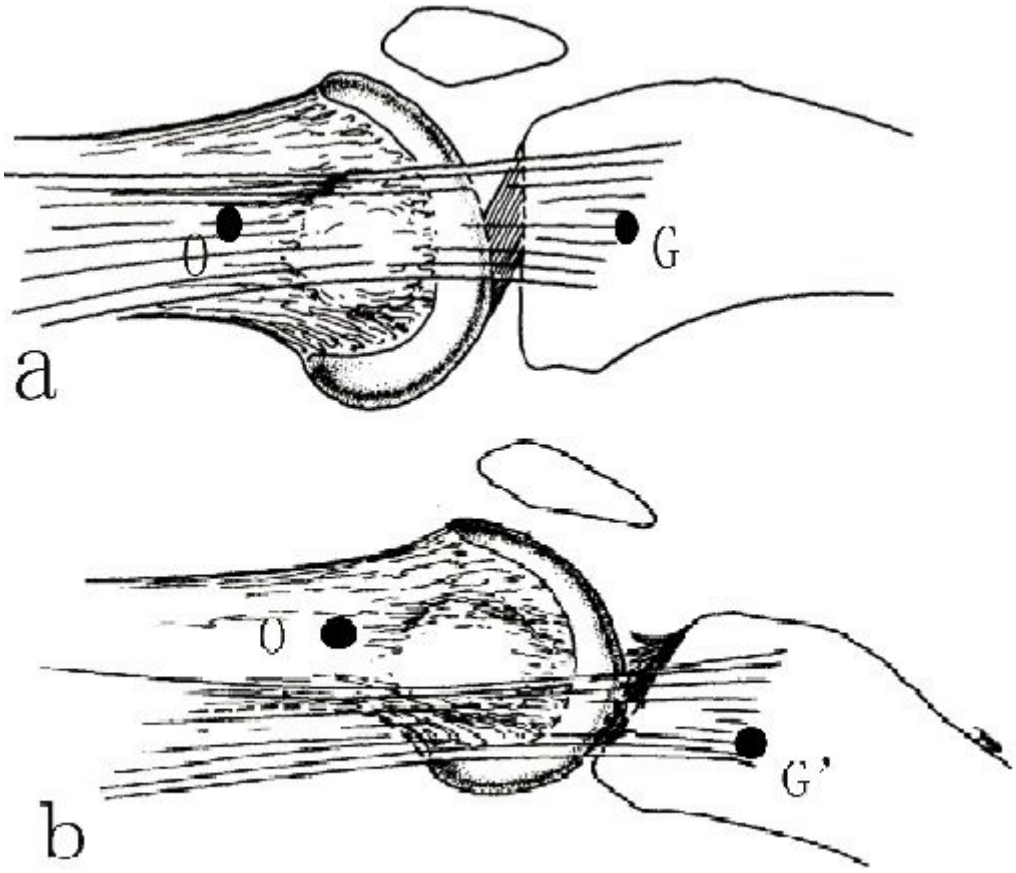

Figure 3

The distance OG’ required for knee flexion is longer than OG, and when flexing the knee, the iliac tibia bundle slides downward and backward(a,b).