Fixator-Assisted Nailing for Managing Slipped Capital Femoral Epiphysis Sequelae: A Novel Technique

A Case Report

Majdi Hashem, MD, SB-ortho, and Raheef Alatassi, MD, MSc

Investigation performed at the Department of Orthopedic Surgery, Security Forces Hospital, Riyadh, Saudi Arabia

Abstract

Case: An 18-year-old man with a slipped capital femoral epiphysis treated within in situ screw fixation 5 years earlier presented to our clinic with hip pain, limping, and limited range of motion (ROM) of the left hip. Fixator-assisted nailing (FAN) accompanied by double femoral osteotomies was performed to treat the proximal femoral deformity. At follow-up, the patient had regained full ROM and acceptable alignment of the left lower limb.

Conclusion: The FAN approach effectively manages proximal femoral deformities in select patients. It requires careful analysis of the deformity, meticulous preoperative planning, and surgeons familiar with both intramedullary nailing and external fixation techniques.

Slipped capital femoral epiphysis (SCFE) is a well-known disease that affects the hips of adolescents. It begins with disruption of the capital growth plate and culminates with the displacement of the proximal femoral metaphysis from the capital femoral epiphysis[1,2]. Several sequelae typically occur after a SCFE, and these include residual proximal femoral deformity, coxa vara, and lower limb length discrepancy (LLD)[3,4]. Regarding the biomechanics of coxa vara, the forces on the hip are converted to shearing rather than compressive forces. Therefore, the appropriate surgical osteotomy required to treat and/or prevent the deformity can often be difficult to achieve[5,6]. Traditionally, a valgus subtrochanteric osteotomy is performed to correct coxa vara; however, it may be complicated by a recurrence rate as high as 50%[6].

We describe a novel technique for treating the coxa vara, femoral retroversion, symptomatic impingement, and LLD sequelae of a SCFE initially treated with in situ screw fixation. The patient described herein was managed with a novel surgical technique comprising a fixator-assisted nailing (FAN) and double femoral osteotomies.

The patient was informed that data concerning the case would be submitted for publication, and he provided consent.

Case Report

An 18-year-old man, who denied a history of previous medical conditions or illnesses, presented at another hospital at 12 years of age for left hip pain. Plain radiography showed a left hip SCFE that was subsequently treated with in situ screw fixation (Fig. 1). His follow-up in the first year was uneventful.

Five years later, he was referred to our hospital for limping and decreased left hip range of motion (ROM). His left hip also demonstrated several residual SCFE deformities that included coxa vara, pistol grip deformity, and femoral retroversion (Fig. 2). Furthermore, the patient's height was 172 cm, his left lower extremity was 2 cm shorter than the right, and his left hip demonstrated excessive external rotation and decreased ROM (Table I).

Surgical management was recommended and included the application of a monolateral external fixator, transverse subtrochanteric osteotomy, femoral diaphyseal osteotomy, and the insertion of a femoral intramedullary nail (IMN). After general anesthesia had been induced, the patient was placed in a supine position on the traction table. Fluoroscopy was used to target both the hip and knee in 2 planes (sagittal and coronal). Precise positioning was confirmed before sterilizing and draping

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSCC/B136).

Fig. 1

Fig. 2

Fig. 1 Abduction radiograph of the left hip showing coxa vara and pistol grip deformity. **Fig. 2** Anteroposterior radiograph of the left hip showing failed in situ screw fixation.

the limb, and the fluoroscopic imaging unit was brought into the sterile field from the contralateral side of the table. A pair of external fixator pins was inserted perpendicular to the anatomical axis toward the center of the femoral head in the frontal plane. The pins were separated by approximately 20 mm, with the distal pin being placed approximately 5 mm above the lesser trochanter and at the anterior aspect of the femur in the lateral plane to allow for IMN insertion. Next, 2 Schanz pins were placed distally and perpendicular to the anatomical axis of the distal femur removed from the planned distal tip of the IMN and well anterior to the IMN track to avoid anterior notching if a larger IMN is used (Fig. 3). External fixator longitudinal bars were subsequently attached to the proximal and distal pins, using swivel and conventional clamps, respectively. Percutaneous vent holes were then created at the level of the subtrochanteric osteotomy with a 4.8-mm drill bit before intramedullary reaming to reduce the intramedullary pressure and to allow autograft dissemination at the osteotomy site. The entry point for the IMN, the TRIGEN◊ INTERTAN IMN (Smith & Nephew), at the medial edge of the greater trochanter was established and verified on both the coronal and sagittal planes on radiography. A long olive tip guidewire was inserted, and the IM reaming was achieved when the canal reamed 2 mm above the proposed nail size. A transverse subtrochanteric osteotomy was completed using a 10-mm osteotome with the guidewire in place. With the clamp distractor osteotomy site slightly open, a pair of T-handles were connected to the proximal pins attached to the swivel clamp, and varus correction was achieved by manipulating the pins to the desired angle under fluoroscopic guidance; the limited correction angle of 25° can be

TABLE I Range of Motion of Left Hip Before Osteotomy

Parameter	Result
Internal rotation*	0°
External rotation*	110°
Flexion	80°
Extension	0° (full)
Abduction	15°
Adduction	10°

*Both internal and external rotations were assessed in flexion.

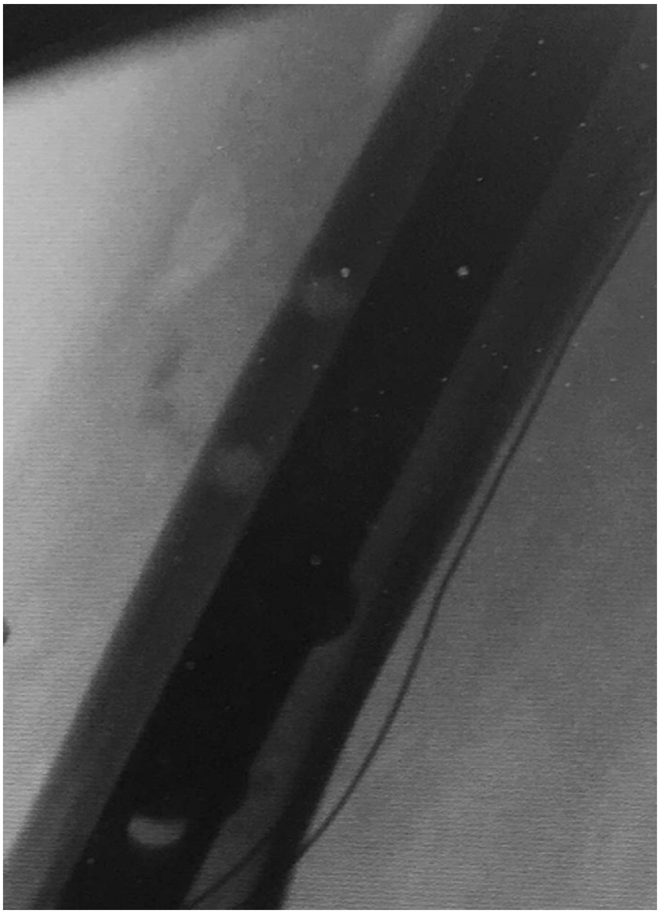

Fig. 3
Intraoperative radiograph showing the distal Schanz pins anterior to the nail.

overcome by removing the blocking screw from the swivel clamp (Fig. 4). Lateral translation was optimized by temporarily placing the Schanz pins on the middle clamp after minimal release of the pins attached to the distal clamp. A small bony wedge was excised from the lateral cortex of the proximal segment to facilitate IMN insertion without disrupting the lateral translation achieved earlier. The IMN was advanced to the diaphysis where a middiaphyseal transverse osteotomy was performed to allow for correction of the femoral rotation. The IMN was advanced into the distal femur and proximal head compression, and lag screws were inserted. The external fixator longitudinal bar was removed without removing the Schanz pins to permit final rotational correction of the distal femur. Approximately 45° of internal rotation of the femur was achieved, and distal interlocking screws were inserted (Fig. 5). Full weight-bearing ambulation was initiated on the first postoperative day with crutches, and the patient began walking independently within 2 weeks.

After 6 weeks, there were no complications, and both osteotomies were stable without lateralization with the IMN in place (Fig. 6). Two years after surgery, radiography demonstrated complete union of both osteotomy sites (Fig. 7). Moreover, the left lower limb realignment was maintained with the left femoral neck shaft angle corrected to 123° and the LLD was equalized (Fig. 8). The patient had satisfactory left hip ROM, as shown in Table II, without any residual hip pain.

Discussion

This complicated case presented an enormous clinical challenge because of the severe sequelae of the patient's previous SCFE. All of the patient's left hip and limb malalignment issues had to be addressed to achieve a reasonable functional outcome.

FAN has recently been gaining popularity in the treatment of lower limb deformities. This technique reduces the need for large, open approaches, and, thereby, involves less dissection and soft-tissue damage, bleeding, scarring, and postoperative pain[7-10]. A more extensive open subtrochanteric osteotomy approach would require an angled blade plate, a large incision with subsequent disruption of the related soft tissues, and possibly an additional surgical procedure to remove this more prominent hardware. FAN application for the correction of long-bone malalignment has been described in the literature on deformities of the knee, tibial

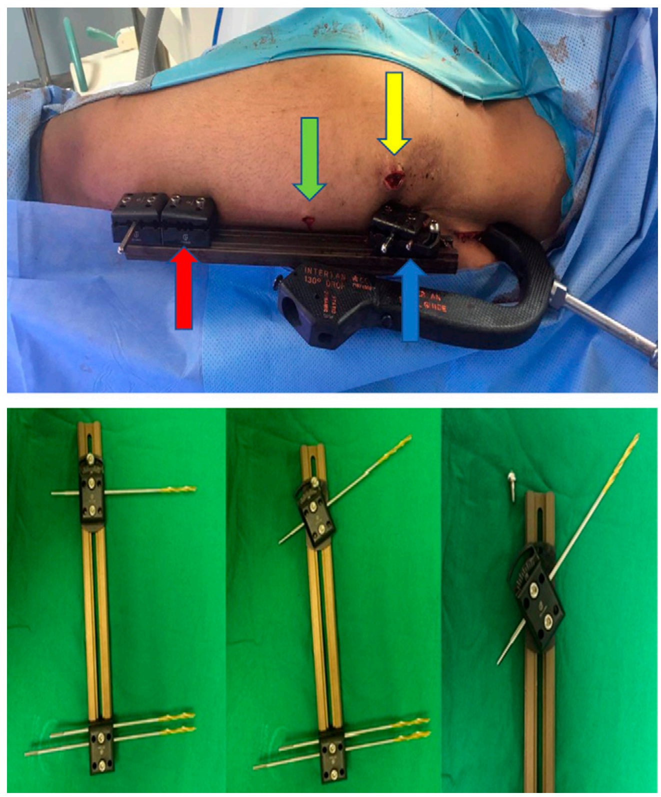

Fig. 4
Fig. 4-A Intraoperative photograph showing various important structures: middle clamp (red arrow), swivel clamp (blue arrow), small incision to apply temporary Schanz pins to facilitate control of lateral translation and to perform subsequent midshaft osteotomy (green arrow), and small incision to perform subtrochanteric transverse osteotomy (yellow arrow). **Fig. 4-B** Photograph showing the external fixator that has been used with the Schanz pins.

Fig. 5-A

Fig. 5-B

Fig. 5-A Anteroposterior radiograph of the left hip showing the proximal head screw in place after correction. **Fig. 5-B** Anteroposterior radiograph of the left femur showing the intramedullary nail in place after correction.

shaft, and femoral shaft[8-11]. To date, the proximal femur application of this technique has been limited to subtrochanteric nonunions[12].

The reported incidence of nonunion after subtrochanteric femoral osteotomy ranges from 1.3% up to 20%[13-15]. This FAN technique maintains the anatomy and provides mechanical

Fig. 6-A

Fig. 6-B

Fig. 6-A Anteroposterior radiograph of the left hip 6 weeks after surgery showing the proximal head screw in place after correction. **Fig. 6-B** Anteroposterior radiograph of the left femur 6 weeks after surgery showing the intramedullary nail in place after correction.

Fig. 7-A

Fig. 7-B

Fig. 7-A Lateral radiograph of the left hip 2 years after surgery showing complete union at the site of subtrochanteric transverse osteotomy. **Fig. 7-B** Anteroposterior radiograph of the left femur 2 years after surgery showing complete union at the site of midshaft osteotomy.

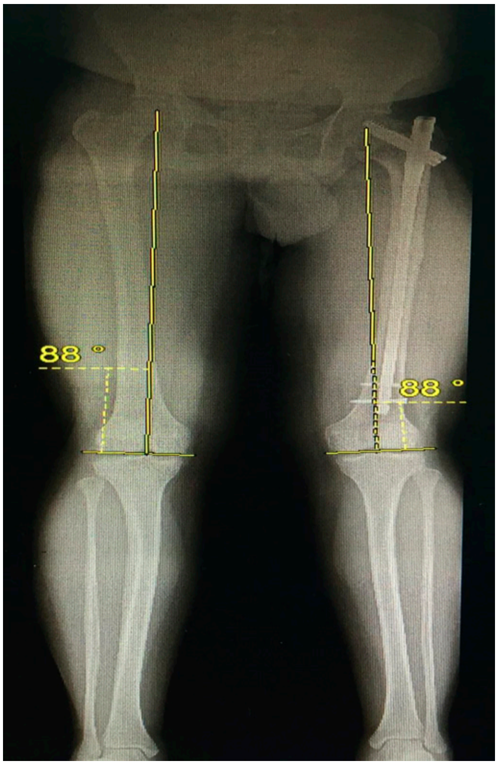

Fig. 8-A

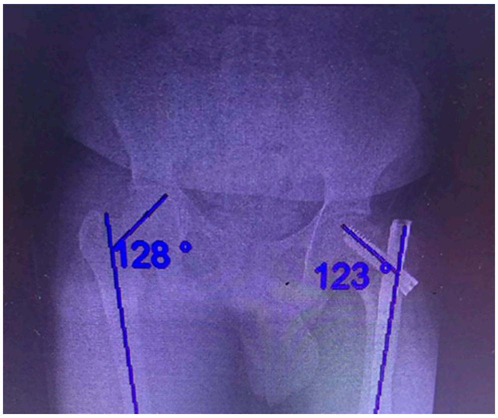

Fig. 8-B

Fig. 8-A Full-length lower limb radiograph showing corrected alignment of the left lower limb. **Fig. 8-B** Anteroposterior radiograph of the pelvis showing femoral neck angles on both sides.

TABLE II Range of Motion of Left Hip 1 Year After Osteotomy

Parameter	Result
Internal rotation*	45°
External rotation*	45°
Flexion	120°
Extension	0° (full)
Abduction	40°
Adduction	15°

*Both internal and external rotations were assessed in flexion.

stability by eliminating most of the factors, leading to delayed union or nonunion. Such factors include uncontrolled motion at the osteotomy site, the deforming forces causing persistent varus and procurvatum to the proximal femoral fragment, lack of autografting provided by canal reaming, and soft-tissue stripping. Furthermore, the IMN is biomechanically superior to plate fixation because it is closer to the hip center of rotation and provides a longer working length. The centromedullary position and cephalomedullary extension of IMN prevents mechanical failures by acting as a buttress against uncontrollable medialization. Thus, the risk of losing deformity correction is decreased. Finally, full weight-bearing is tolerated immediately after surgery[16]. In addition, because of the alignment control provided by the external fixator, osteotomy can be performed using a less-invasive technique minimal bony manipulation, and minimal disruption of the blood supply at the osteotomy site.

The disadvantage of our technique is performing the osteotomy far away from the center of rotation of angulation in comparison with other proximal osteotomy types, which have the advantage of achieving better control of deformity correction without the need for translation. We overcome this limitation by using the external fixator to maintain the correction until the definitive fixation has been applied. Moreover, compared with other reconstructive procedures, our approach offers simplicity in executing the osteotomy, minimal invasiveness, and control of deformity correction. Most of the existing subtrochanteric osteotomy techniques described in the literature were stabilized by a variety of plates and screws, and all subsequent hip procedures have had to include implant removal. However, performing a subtrochanteric osteotomy for hip deformity correction will require bony translation. This translation would alter the femoral canal conformation and further complicate any subsequent total hip arthroplasty considerations. We believe that using this type of fixation will encounter more translation and canal obliteration than using IMN fixation as in our case. However, proximal femoral osteotomy with the FAN technique utilization does not jeopardize the outcome of future total hip arthroplasty enough to exclude the use of osteotomy as a therapeutic method in younger patients.

This patient was treated using FAN with subtrochanteric osteotomy for proximal femoral deformity and is the first reported case using this technique for treating proximal femoral deformity resulting from SCFE. Follow-up of the patient demonstrated satisfactory outcomes in pain, alignment, and ROM.

Conclusion

In conclusion, the FAN technique is an effective method for treating proximal femoral deformities. It requires careful analysis of the deformity, meticulous preoperative preparation, and a surgeon familiar with both intramedullary nailing and external fixation techniques. ■

Note: The authors sincerely thank the Security Forces Hospital, Department of Orthopedic Surgery for their enthusiastic assistance. Dr. Alatassi is now affiliated with the Department of Orthopedic Surgery, McGill University Health Centre, Jewish General Hospital, Montreal, Canada.

Majdi Hashem, MD, SB-ortho[1]
Raheef Alatassi, MD, MSc[2]

[1]Department of Orthopedics, College of Medicine, Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia

[2]Department of Orthopedic Surgery, Security Forces Hospital, Riyadh, Saudi Arabia

E-mail address for R. Alatassi: Raheef.alatassi@mail.mcgill.ca

ORCID iD for M. Hashem: 0000-0001-5769-3846
ORCID iD for R. Alatassi: 0000-0003-0822-1118

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