RECURRENT ROTATIONAL DEFORMITY OF THE FEMUR AFTER STATIC LOCKING OF INTRAMEDULLARY NAILS

CASE REPORTS

CHRISTIAN KRETTEK, THEODORE MICLAU, MICHAEL BLAETH, RONALD W. LINDSEY,
CHRISTIAN DONOW, HARALD TSCHERNE

From the Hannover Medical School, Germany

Rotational deformity following intramedullary nailing may cause symptoms and require surgical correction by osteotomy. Reamed, locked intramedullary nailing may be performed, but concern about cortical blood supply and potential pulmonary dysfunction from reaming have led many surgeons to limit this and use smaller diameter nails. Slotted nails are commonly used but are less stiff in torsion than the newer unslotted nails, particularly at the lower diameters.

We report two cases of recurrent femoral rotational deformity after using statically interlocked slotted intramedullary nails to correct existing femoral rotational deformities. These patients show that small diameter statically interlocked femoral nails with diminished bone-nail contact must be stiff enough in rotation to avoid potential recurrence.

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Intramedullary nailing is commonly used for the fixation of fractures of the femoral shaft. Rotational deformity after nailing is a well-known complication and can occur during or after operation if locking is not used.¹ Occasionally, such a deformity can cause symptoms and require correction,^{1,2} often by osteotomy with a reamed, locked intramedullary nail.² There are some concerns, about the adverse effects of

reaming on the cortical blood supply^{3,4} and the potential pulmonary effects.^{5,6} This has prompted a number of surgeons to limit reaming and to use nails of smaller diameter.⁷ Slotted nails are usually inserted, but they are less stiff in torsion than the newer unslotted nails, particularly at smaller diameters⁷ (Table I). The effect of the decreased torsional stiffness of these interlocked nails of small diameter has not been well established.⁸

We report two cases of recurrent femoral rotational deformity after the use of statically interlocked slotted intramedullary nails for the correction of a previous femoral rotational deformity. They illustrate one risk of using slotted femoral intramedullary nails of small diameter.

Table I. Calculated stiffness (Nm^2) and rotational deformation (degrees) at 4 Nm for slotted and unslotted nails of different diameters. The slot width was 0.7 mm; all other parameters were the same for the calculations of slotted and unslotted nails: profile, round tube; wall thickness, 1.2 mm; working length, 350 mm; shear modulus for stainless steel: 75.19 GPa. For comparison, a moment of torque of 4 Nm is usually applied when a 4.5 mm cortical screw is tightened.⁹

Outside diameter (mm)	Slotted*		Unslotted	
	Torque stiffness	Rotational deformation	Torque stiffness	Rotational deformation
11	1.3	60.8	67.7	1.2
12	1.4	55.3	90.4	0.9
13	1.6	50.5	117.6	0.7
14	1.7	46.4	149.9	0.5
15	1.9	43.1	187.6	0.4
16	2.0	40.3	231.2	0.3
17	2.1	37.5	281.1	0.3
18	2.3	35.3	337.7	0.2

* The calculations are based on equations from Kenedi¹⁶ and Tencer and Johnson.¹⁷ The full equations are available on request from the author.

C. Krettek, MD, Professor, Trauma Surgeon
M. Blauth, MD, Privatdozent, Trauma Surgeon
C. Donow, MD, Resident in Trauma Surgery
H. Tschorne, MD, Professor, Head of Trauma Department
Hannover Medical School, D 30623 Hannover, Germany.

T. Miclau, MD, Assistant Professor, Orthopaedic Surgeon
Department of Orthopaedic Surgery, San Francisco General Hospital,
1001 Potrero Avenue, Room 3A36, San Francisco, California 94110,
USA.

R. W. Lindsey, MD, Associate Professor, Orthopaedic Surgeon
Department of Orthopaedic Surgery, Baylor College of Medicine, 6550
Fannin, Suite 2625, Houston, Texas 77030, USA.

Correspondence should be sent to Dr C. Krettek.

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Case 1. A 20-year-old man sustained a closed midshaft fracture of the left femur in a motor-vehicle accident. At a local hospital a proximally locked reamed 12 mm AO Universal intramedullary nail (Synthes, Bochum, Switzerland) was inserted. The fracture healed uneventfully but the

Fig. 1a

Fig. 1b

Case 1. Figure 1a – Radiographs showing a healed complex transverse fracture of the midshaft of the femur fracture. Internal rotation of the hip is seen with the knee in an anteroposterior projection. Figure 1b – CT shows a left femoral external rotation deformity of 36°.

patient noted an increase in external rotation of his leg. Eleven months after the injury he complained of low-back and hip pain which had prevented his return to sport, and examination confirmed an external rotation deformity of the femur. Plain radiographs showed a healed fracture (Fig. 1a) and CT confirmed a 36° external rotation deformity of the left femur (Fig. 1b).

We performed a transverse midshaft femoral osteotomy, using a reamed 12 mm slotted statically interlocked AO Universal nail to stabilise the bone.⁹ Rotational correction was controlled and confirmed by the use of Kirschner wires and a fixed-angle template (Fig. 1c).¹⁰ Postoperatively, partial weight-bearing (15 kg) was allowed.

Within the first month after operation, the patient noted a gradual painless return of his rotational deformity. On routine follow-up at six and 11 months, he showed 35° of rotational malalignment (Fig. 1d). Radiologically, his osteotomy had fully healed, and he was discharged and allowed unrestricted activities.

Over the next two years, he developed hip and anterior knee pain severe enough to stop him playing soccer. Examination at 2.5 years after the correctional osteotomy the clinical external rotational deformity was 35°, plain radiographs showed a healed osteotomy with the nail in place,

and CT demonstrated external rotational malalignment of 41° and 1 cm of femoral shortening (Fig. 1e). The patient was then treated by an oblique derotational wedge osteotomy stabilised by a plate (Fig. 1f), producing symmetrical hip rotation; CT showed 6.8° of external rotation (Fig. 1g). The postoperative course was uneventful, and at the 12-week follow-up, the correction was maintained.

Case 2. A 22-year-old man sustained an isolated, closed simple transverse midshaft fracture of the left femur after a motorcycle accident. His fracture was stabilised by a reamed 12 mm AO Universal intramedullary nail (Synthes, Bochum, Germany) without interlocking screws. The fracture healed uneventfully, but with an external rotational deformity of 30°.

He was allowed to return to full activities, but over the first postoperative year had persistent hip and anterior knee pain. After three years, pain and the appearance of the leg had prevented him from running. Plain radiography showed a well-healed fracture and CT an external rotational deformity of 32°. A transverse midshaft osteotomy was fixed with a reamed 12 mm slotted AO Universal nail which was statically locked,⁹ using Kirschner wires and a fixed-angle template to ensure good correction.¹⁰ Postoperatively, partial weight-bearing (15 kg) was allowed.

Fig. 1c

Fig. 1d

Figure 1c – Radiographs taken immediately after osteotomy and statically locked intramedullary nailing show correction of the rotational deformity. The hip and knee are both in an anteroposterior projection. Figure 1d – Radiographs one year after correction showing a well-healed osteotomy and the return of rotational deformity.

Fig. 1e

Figure 1e – CT showing an external rotation deformity of 41°.

Fig. 1f

Fig. 1g

Figure 1f – Radiographs taken immediately after the second osteotomy show correction of the rotational deformity and osteosynthesis using a plate. Figure 1g – CT after the second osteotomy showing a residual difference in external rotation of only 6.8°.

The osteotomy healed uneventfully, but there was a gradual return of the deformity in the early postoperative period. CT showed external rotational malalignment of 20°, and the patient was still unable to play sports because of hip and knee pain. He was also unhappy with the appearance of his leg.

Six years after the original injury and three years after the previous osteotomy, a transverse osteotomy was stabilised by an unslotted 12 mm unreamed femoral nail (Synthes, Bochum, Germany), with rotational correction controlled by wires and a template. The postoperative course was uneventful and partial weight-bearing (15 kg) was allowed from the start. At five months, the patient was painfree and no clinical deformity was detectable.

DISCUSSION

Post-traumatic femoral rotational deformities are successfully treated by osteotomy and statically locked intramedullary nailing.² Success depends on adequate torsional stiffness of the nail to maintain the corrected alignment. In the past, reamed slotted nails of large diameter have been used which achieve stability by increasing the bone-nail contact area.¹¹ Despite the clinical success of reamed intramedullary nailing, limited reaming has become increasingly popular because it causes less devascularisation of cortical bone and fewer pulmonary complications.^{3,5,6} Torsional stiffness decreases with decreasing nail diameter,

particularly for slotted nails (Table I) and the effects of this with static locking are uncertain.⁸

Our cases illustrate the risk of using slotted locked nails of small diameter when torsional forces on the implant may be high. To our knowledge, these are the first cases to be reported after statically locked nailing.

Some authors have reported that few clinical problems are caused by torsional femoral deformity,¹²⁻¹⁴ but others have found these to be more common with torsion of over 15°.¹ The cause of pain and the consequences of femoral rotational deformities are unclear,¹⁵ but such patients may have considerable hip and anterior knee symptoms.

The torsional stiffness required for the stable fixation of femoral fractures and osteotomies is uncertain, and it seems that statically interlocked femoral nails of small diameter need to be stiff in torsion if they are to control rotation adequately and avoid deformity. We conclude that in such cases, if reaming is to be avoided, a torsionally stiff implant such as an unslotted nail or a plate should be used to stabilise a rotational osteotomy.

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