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Assessment and correction of femoral malrotation following intramedullary nailing of the femur

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Rotational deformity is a more common problem than one might expect in the treatment of femoral shaft fractures. This review presents two cases of femoral malrotation following intramedullary nailing of the femur. The presentation, importance of early recognition, investigation with a CT scan, and the technique of correction is discussed in detail. The importance of intra-operative assessment to avoid this complication is highlighted and a review of the current literature on this problem and its treatment is presented.

Key words : femur ; fracture ; rotation ; alignment.

INTRODUCTION

Intramedullary nailing of the femur has become the gold standard for the treatment of femoral shaft fractures in the skeletally mature population (*22,23*). It is a commonly performed procedure with a low rate of complications and a high rate of union 98 – 99% (*22,23*). However complications do occur and femoral malunion is more common than one may expect (*2,11,14,17,22,23*). Some series fail to comment upon rotational malalignment and those that do, define rotational malalignment differently. However, when it is reported, it is the most common form of malunion ranging from 8% to 28% (*2,11,19,22*). Careful attention to detail intra-operatively helps in avoiding this complication especially at the stage of proximal and distal locking of the intramedullary device.

This review describes our experience with two patients who presented to our institution with femoral malrotation following intramedullary nailing at other institutions. The assessment in terms of clinical findings and pre-operative planning, operative technique for correction and tips on avoiding this complication are presented and the current literature on the subject is reviewed.

CASE REPORTS

Case 1

A 45-year-old male sustained a closed, mid-shaft fracture of the femur whilst skiing in Austria. He underwent fixation of his femoral fracture with a TriGen® (Smith and Nephew) intramedullary nail in Austria. Traction during the procedure was

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obtained using a supracondylar pin. He was referred to our institution for follow-up upon his return to the United Kingdom. Clinical assessment six days post-operatively revealed that the wound was healing nicely and the overall alignment of the limb was satisfactory. However, he was noted to have an excessive amount of internal rotation and no external rotation in the affected lower limb. A CT scan was arranged to assess the deformity and he was found to have a 30° internal rotation deformity of the femur compared with the normal side.

Case 2

A 15-year-old boy fell off his bicycle and sustained a mid-shaft fracture of the femur, which was treated with a reamed intramedullary nail on a fracture table with no skeletal traction. Due to difficult family circumstances his follow-up was disjointed. He first review occurred at 8 weeks following surgery. At this point he was comfortable, the wounds had healed and had been fully weight bearing for two weeks. However, over the course of the past few weeks he had noticed that he could almost point the foot of his injured leg backwards by internally rotating the leg when this had never been possible prior to surgery and was certainly not a feature on the normal side. Clinical examination revealed that he had no external rotation and excessive internal rotation of the affected side. Antero-posterior and lateral radiographs demonstrated good overall alignment and early callus formation (fig 1). However, in view of the clinical deformity a CT scan was arranged which demonstrated an internal rotation deformity of 35° compared with the normal side (fig 2).

OPERATIVE TECHNIQUE

The CT had been performed in both patients preoperatively to exactly quantify the amount of rotational malalignment, as measuring this precisely can be difficult clinically. The radiologists used the same methods as those used for assessing rotational problems in children described by Jeanmart *et al* (*13*). The method described by Jeanmart *et al* has

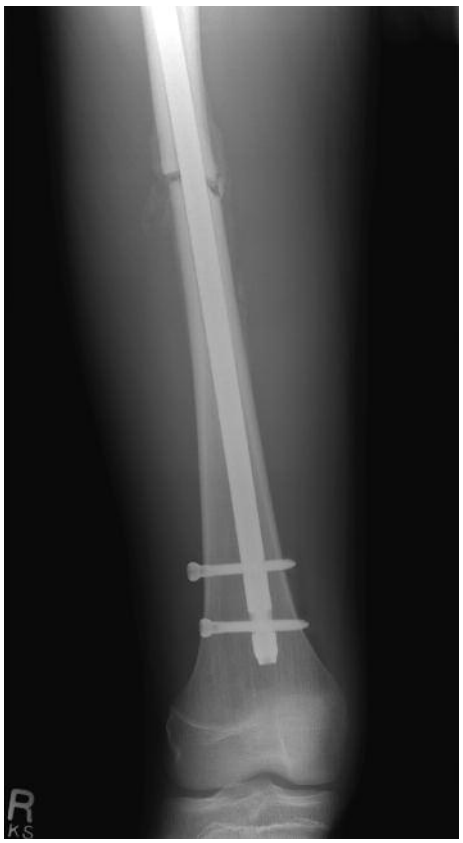

Fig. 1. — Pre operative radiograph demonstrating early callus

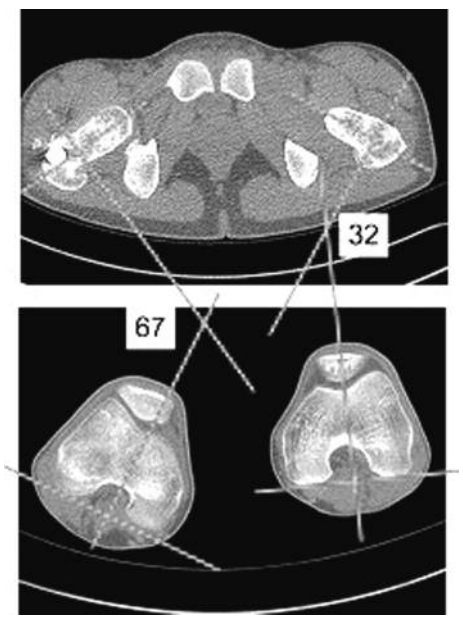

Fig. 2. — CT assessment of the rotational alignment using the method described by Jeanmart.

been used in the assessment of rotational malalignment following intramedullar nailing of the femur. Scans were obtained at the same level through the femoral neck region, femoral condyles and the distal tibia. When each scan is compared with the neutral axis, usually the ground, an exact idea of the degree of deformity and the level of deformity can be achieved.

Following appropriate pre-operative counseling and consent, both the patients were admitted for correction of the rotational malalignment. The patients were positioned on a radiolucent fracture table with the leg free ; prophylactic antibiotics were administered prior to the procedure.

Both patients had demonstrated a good amount of callus formation pre-operatively and therefore the fracture site was exposed using a vastus splitting incision. Any callus that would prevent rotation of the fracture was removed or disrupted. The distal locking screws were removed and a K-wire was placed on either side of the fracture site, the distal K-wire being rotated in the direction and magnitude equal to the rotational deformity measured on the pre-operative CT scan. The distal femur was allowed to rotate on the intramedullary nail until the K-wires became parallel to each other ensuring that the deformity was corrected accurately. As these patients had such a significant rotational deformity it was possible to place new distal locking screws through new drill holes without interference from the previous insertion site for the locking screws. The patients were allowed to weight bear as pain allowed and rehabilitation resumed. Both patients achieved full union with normal range of movement and return to pre-injury functional status at six months with no complications.

DISCUSSION

Femoral malrotation following fractures of the femoral shaft has always been a problem as it is difficult to correct and maintain correction with non-operative treatment methods. The advent of the locked solid or larger diameter cannulated intramedullary femoral nail has allowed for excellent control of femoral rotation and therefore in theory should have resolved this issue. Unfortunately, assessing rotation intra-operatively can be a difficult task especially in multifragmentary fractures and is usually done by intra-operative clinical assessment. Although the use of the profile of the lesser trochanter has been described as a radiological marker that can be used intra-operatively (*12*), it has not gained widespread acceptance. Clinical assessment whilst the patient is under general anaesthesia is also difficult. Most surgeons use the ankle or patella and try to align them symmetrically with the unfractured side or the floor but this does not take into account the position of the proximal fragment and could be moved during reduction attempts. In addition intramedullary nailing of the femur can be undertaken in the lateral decubitus position without traction as well as supine on a traction table with traction provided through a boot or a Steinman pin. Advocates describe the benefits of each method but there does not appear to be any significant difference between the rates of rotational malalignment (*18*). As all methods of rotational assessment are difficult and potentially unreliable one needs to be extremely vigilant for problems. Utilisation of both radiological and clinical assessment techniques comparing with the normal side should help prevent problems (*24*). It is due to these difficult and inexact methods of assessing the rotation that problems are likely to occur.

Recent advances in computer navigation and in particular the development of more reliable non invasive markers for the uninjured side (*15*) make the use of computer navigation in the setting of trauma more attractive. Studies have demonstrated that the injured femur can be accurately locked to match the femoral anteversion on the uninjured side (*6,8,16*). In a comparative study, the probability of rotational deformities beyond 15° by the use of navigation was markedly reduced (*6*). The use of computer aided navigation has not yet been widespread but as navigation becomes more widely available it will inevitably become more cost effective to include its use in the trauma setting.

Quantifying rotational malalignment accurately in the post-operative period is a difficult task as well. Clinical assessment has been demonstrated to be unreliable in the past (*1,11*) and therefore other methods have been developed. Some centers have

used ultrasound but this is very operator dependent (*1,2,19*). Radiographs are unreliable as it is not possible to quantify the rotational deformity without difficult patient positioning. MRI can be used in the same way as CT, but is not readily available and is time consuming and expensive. The most commonly used and accepted gold standard assessment is that described by Jeanmart *et al* (*13*) using CT scans.

Side to side differences in femoral neck anteversion of up to 10° among normal subjects are relatively common (*1*). Braten *et al* (*2*) found that most malalignment problems occurred at the time of surgery but those patients with less than 10° of difference when compared with the normal side rarely complained. However, once the difference rose to above 15° the patients often perceived it as a problem and above 30° of side-to-side difference serious complaints likely. It has also been demonstrated (*7*) that alteration in the rotational axis of the femur leads to significant alteration in the weight-bearing axis if it exceeds 30° in the subtrochanteric region or 45° in the midshaft. Alteration in the rotational alignment of the limb can be demonstrated on gait analysis by alteration in the foot progression angle (*10*). It is perhaps not surprising that larger degrees of malrotation lead to a higher incidence of hip, knee and ankle osteoarthritis (*5*).

Series looking at the outcomes of intramedullary femoral nailing describe the incidence of malrotation as being surprisingly high, ranging from 8 to 28% (*2,11,19,22*) with no difference in rotational problems when comparing antegrade versus retrograde femoral nailing (*19*). The majority of these rotational problems have been detected because they have been looked for as part of the studies being conducted, but they are not noticeable to the patient and therefore are not relevant clinically. Most studies do not report further intervention as being necessary.

Once full union has occurred the only way to correct rotational alignment is with an osteotomy and this can be performed around the nail or using Ilizarov's principles (*3*) but more often a subtrochanteric osteotomy (*20*) is utilised. This requires a fairly invasive surgical approach although Stahl *et al* (*21*) and Itoman *et al* (*9*) recommend closed intramedullary sawing as an option.

Our patients had a clinically obvious deformity that was quantified by an early CT scan. Both our patients had very significant rotational malalignment that was likely to lead to serious complaints ; therefore we decided to intervene early. This allowed rotation of the femur on the original intramedullary nail after a relatively small incision to allow clearance of any early callus at the original site of the fracture. As the amount of rotation required was significant, new locking holes could be created without a major problem but one can envisage this not being the case in minimal amounts of correction.

Rotational malalignment is a well-documented problem following intramedullary nailing of the femur, and great care should therefore be taken during the procedure to try and prevent this complication. Careful attention to detail must be exercised while reducing the fracture and final assessment of rotation made clinically and radiologically before both ends of the nail are locked. Patients should also be assessed carefully clinically for problems in the early post-operative period and if gross abnormalities are identified a CT assessment should be arranged to accurately quantify the degree of malrotation. If this is below 15° then the patient can be reassured as it is unlikely to cause a problem. A difficult area is when the deformity is between 15-30° , some clinical judgment and discussion with the patient should occur before embarking upon surgical correction, as a large proportion of people will tolerate this deformity. It may also be more difficult to reposition the locking screws without them falling into the previous tracks. It is our belief that if the deformity is larger than 30°, it is almost certain to cause the patient some level of disability in the future and should be treated. When treated early it can be relatively easy and safe to correct large degrees of malrotation by the method described above.

It is only by careful assessment in the post-operative period that problems like this can be identified and when treated expediently can lead to simpler treatment options, reduced overall treatment time and morbidity.

REFERENCES

1. **Bråten M, Terjesen T, Rossvoll I.** Femoral anteversion in normal adults : ultrasound measurements in 50 men and 50 women. *Acta Orthop Scand* 1992 ; 63 : 29-32.
2. **Bråten M, Terjesen T, Rossvoll I.** Torsional deformity after intramedullary nailing of femoral shaft fractures. Measurement of anteversion angles in 110 patients. *J Bone Joint Surg* 1993 ; 75-B : 799-803.
3. **Brinker MR, Gugenheim JJ, O'Connor DP, London JC.** Ilizarov correction of malrotated femoral shaft fracture initially treated with an intramedullary nail: a case report. *Am J Orthop* 2004 ; 33 : 489-493.
4. **Dugdale TW, Degnan GG, Turen CH.** The use of computed tomographic scan to assess femoral malrotation after intramedullary nailing. A case report. *Clin Orthop Relat Res* 1992 ; 279 : 258-263.
5. **Eckhoff DG.** Effect of limb malrotation on malalignment and osteoarthritis. *Orthop Clin North Am* 1994 ; 25 : 405-414.
6. **Gösling T, Oszwald M, Kendoff D *et al.*** Computer-assisted antetorsion control prevents malrotation in femoral nailing : an experimental study and preliminary clinical case series. *Arch Orthop Trauma Surg* 2009 ; 129 : 1521-1526.
7. **Gugenheim JJ, Probe RA, Brinker MR.** The effects of femoral shaft malrotation on lower extremity anatomy. *J Orthop Trauma* 2004 ; 18 : 658-664.
8. **Hofstetter R, Slomczykowski M, Krettek C *et al*.** Computer-assisted fluoroscopy-based reduction of femoral fractures and antetorsion correction. *Comput Aided Surg* 2000 ; 5 : 311-325.
9. **Itoman M, Sekiguchi M, Yokoyama K, Minamisawa I.** Closed intramedullary osteotomy for rotational deformity after long bone fractures. *Int Orthop* 1996 ; 20 : 346-349.
10. **Jaarsma RL, Ongkiehong BF, Grüneberg C *et al.*** Compensation for rotational malalignment after intramedullary nailing for femoral shaft fractures. An analysis by plantar pressure measurements during gait. *Injury* 2004 ; 35 : 1270-1278.
11. **Jaarsma RL, Pakvis DF, Verdonschot N, Biert J, van Kampen A.** Rotational malalignment after intramedullary nailing of femoral fractures. *J Orthop Trauma* 2004 ; 18 : 403-409.
12. **Jaarsma RL, Verdonschot N, van der Venne R, van Kampen A.** Avoiding rotational malalignment after fractures of the femur by using the profile of the lesser trochanter : an in vitro study. *Arch Orthop Trauma Surg* 2005 ; 125 : 184-187
13. **Jeanmart L, Baert AL, Wackenheim A.** *Computer Tomography of Neck, Chest, Spine and Limbs. Atlas of Pathological Computer Tomography*. Vol 3. Springer, Berlin, Heidelberg, New york. pp 171-177.
14. **Johnson EE.** Angular malalignment after intramedullary nailing of the femoral shaft. *J Orthop Trauma* 2001 ; 15 : 533-534.
15. **Kendoff D, Citak M, Gardner MJ *et al*.** Navigated femoral nailing using noninvasive registration of the contralateral intact femur to restore anteversion. Technique and clinical use. *J Orthop Trauma* 2007 ; 21 : 725-730.
16. **Khoury A, Liebergall M, Weil Y, Mosheiff R.** Computerized fluoroscopic-based navigation-assisted intramedullary nailing. *Am J Orthop* 2007 : 36 : 582-585.
17. **Ricci WM, Bellabarba C, Lewis R *et al.*** Angular malalignment after intramedullary nailing of femoral shaft fractures. *J Orthop Trauma* 2001 ; 15 : 90-95.
18. **Ricci WM, Gallagher B, Haidukewych GJ**. Intramedullary nailing of femoral shaft fractures : current concepts. *J Am Acad Orthop Surg* 2009 ; 17 : 296-305.
19. **Salem KH, Maier D, Keppler P, Kinzl L, Gebhard F.** Limb malalignment and functional outcome after antegrade versus retrograde intramedullary nailing in distal femoral fractures. *J Trauma* 2006 ; 61 : 375-381.
20. **Samuel AW.** Malrotation of the femur after intramedullary nailing. *Injury* 1996 ; 27 : 438-440.
21. **Stahl JP, Alt V, Kraus R *et al*.** Derotation of post-traumatic femoral deformities by closed intramedullary sawing. *Injury* 2006 ; 37 : 145-151
22. **Winquist RA, Hansen ST Jr, Clawson DK.** Closed Intramedullary nailing of femoral fractures. A report of five hundred and twenty cases. *J Bone Joint Surg* 1984 ; 66-A : 529-539.
23. **Wolinsky PR, McCarty E, Shyr Y, Johnson K.** Reamed intramedullary nailing of the femur : 551 cases. *J Trauma* 1999 ; 46 : 392-399.
24. **Yang KH, Han DY, Jahng JS, Shin DE, Park JH.** Prevention of malrotation deformity in femoral shaft fracture. *J Orthop Trauma* 1998 ; 12 : 558-562.