

Fracture of the ipsilateral neck of the femur in shaft nailing

THE ROLE OF CT IN DIAGNOSIS

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We report retrospective and prospective studies to identify the causes of fracture of the femoral neck associated with femoral shaft nailing on the same side. Of a total of 14 neck fractures in a series of 152 shaft nailings, eight were not visible on the initial pelvic radiographs.

We used CT scans before and after operation, and fluoroscopy during the procedure in our prospective series, and reviewed abdominal CT scans retrospectively with the window set to bone level. Six of the eight undisplaced fractures were shown to have been present before operation, but two were iatrogenic.

We recommend the preoperative use of CT scans of the femoral neck in high-risk patients such as those with associated fractures of the acetabulum, the distal femur or the patella. Early diagnosis will allow better general management and early fixation of the neck fracture.

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Ipsilateral fractures of the shaft and neck of the femur are caused by high-energy trauma, and occur in 1% to 6% of fractures of the femur.¹⁻⁴ The diagnosis of the neck fracture is difficult and between 19% and 50% are missed.^{2,4-11} When they are discovered it may be uncertain whether they were present before operation or occurred during the procedure. Failure to take appropriate radiographs, external rotation of the shaft of the femur and the presence of a subclinical occult fracture may account for preoperative misdiagnosis.^{2,8,12,13} Fractures during nailing may be due

to the penetrating device during preparation of the entry point,¹⁴ lateral insertion of the femoral nail in a small patient,¹⁵ a neck-shaft angle of more than 135°,¹⁶ the medial prong of the insertion jig,¹⁶ or anterior location of the entry hole.¹⁷ We believe that in some cases the state of the femoral neck should be checked before operation by CT or tomogram; this is the only certain way of detecting a subclinical fracture. Displacement of such a fracture during nailing is often regarded as an iatrogenic injury.¹¹

Our aim was to identify lesions in the femoral neck before femoral nailing using preoperative CT or intraoperative fluoroscopy and to investigate the diagnosis of such fractures.

Patients and Methods

In a five-year period we identified 14 fractures of the ipsilateral neck of the femur in association with 152 closed antegrade femoral nailings. Three displaced fractures of the neck were initially diagnosed by radiographs of the pelvis, but the other 11 lesions were not detected on the initial films. The proximal part of the femur was always seen but was often in external rotation.

We were first alerted by observing an undisplaced subclinical fracture of the femoral neck on a CT scan of the pelvis which had been taken to evaluate a fracture of the acetabulum on the contralateral side (case 2, Fig. 1 and Table I). The neck fracture was not visible on radiographs of the pelvis, which included internal and external oblique views of the acetabulum. It became slightly displaced during closed nailing and was fixed by three Knowles pins.

We then reviewed retrospectively all CT scans which had been taken for other purposes in patients who had shaft nailing. The window of abdominal CT scans was changed to bone level, since they had been taken for evaluation of injury to abdominal organs. Intraoperative fluoroscopic findings were reviewed from operation records.

Since July 1995 we have obtained a preoperative CT scan of the femoral neck for all patients before intramedullary nailing for a shaft fracture. After closed nailing the CT scan was repeated to confirm the state of the femoral neck unless a fracture was seen on a plain film or during intraoperative fluoroscopy. Neck fractures were then

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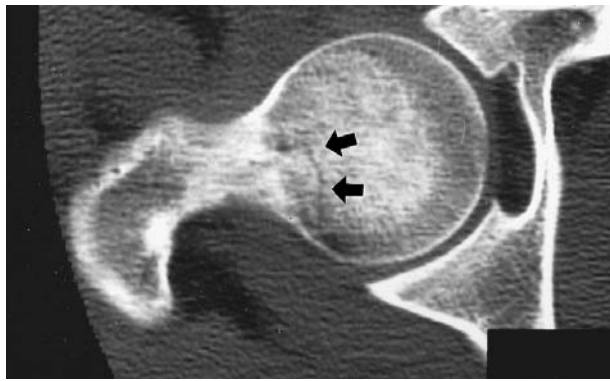


Fig. 1a

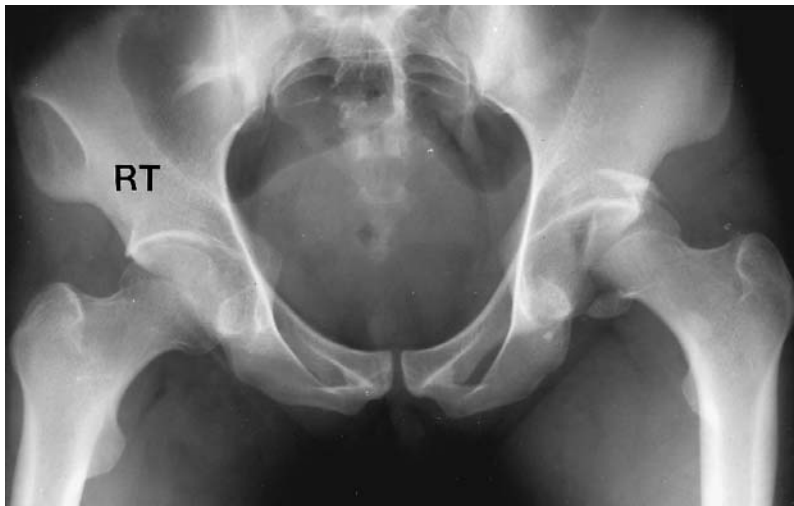


Fig. 1b

Case 2. Figure 1a – This undisplaced fracture (arrows) of the neck of the right femur was found incidentally on a pelvic CT scan taken for the evaluation of an acetabular fracture on the contralateral side. Figure 1b – The proximal right femur seemed intact on the routine pelvic radiograph.

Table I. Details of the eight patients with fracture in the middle-third of the femoral shaft

Case	Femoral shaft	Comm-inution*	Neck-shaft angle (degrees)	Associated fractures	Point of nail introduction	Delay in diagnosis of neck fracture after nailing (days)	Type of neck fracture	Study	Description
1	L	II	132	R femur shaft	Piriformis fossa	21	Subcapital	Retrospective	Subclinical
2	R	II	125	L acetabulum	Piriformis fossa		Subcapital	Prospective	Subclinical
3	R	III	130		Piriformis fossa		Subcapital	Prospective	Subclinical
4†	L	II	132	L intertrochanteric	Greater trochanter		Subcapital	Retrospective	Subclinical
5†	R	IV	132	R medial femoral condyle	Greater trochanter	1	Subcapital	Retrospective	Iatrogenic
6	L	IV	136	R acetabulum	Greater trochanter	30	Subcapital	Prospective	Subclinical
7	L	Seg	128	L greater trochanter	Greater trochanter	21	Base	Prospective	Subclinical
8	L	I	124	L patella, tibia L acetabulum	Greater trochanter		Base	Prospective	Iatrogenic

* Winquist and Hansen¹

† Bilateral fractures of the femoral shaft. The fractures of the left femur were analysed in case 4 and of the right femur in case 5

classified as missed or iatrogenic, depending on the appearances on preoperative CT.

Nailing method. Patients were placed supine on the fracture table for the introduction of an antegrade femoral nail. A pin was inserted at the distal femoral condyle and fixed to the clamp and fracture table. After the skin incision and dissection down through the fasciae, a Steinmann pin was

placed in the appropriate entry point and drilled into the proximal femur. An end-cutting 8 mm reamer was used over the pin to enlarge the entry point. After reduction and passage of a ball-tip guide wire the medullary canal was overreamed by 1 mm. Proximal and distal interlocking screws were inserted as indicated by the pattern of the fracture.



Fig. 2a

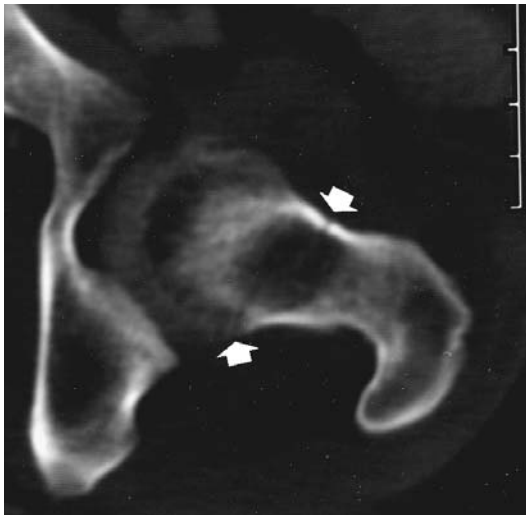


Fig. 2c



Fig. 2b



Fig. 2d

Case 1. A 42-year-old woman sustained bilateral fractures of the femoral shaft. The initial radiograph of the neck of the left femur seemed normal (a) and an abdominal CT scan (b) did not show the undisplaced fracture until the window was changed to bone level retrospectively (c, arrows). The delay in diagnosis and fixation led to varus malunion of the neck (d).

Results

In 152 nailings of the femoral shaft 14 ipsilateral fractures of the neck were identified before or after operation. Three were initially diagnosed on plain radiographs of the pelvis and were caused by the original injury. In three, preoperative CT scans or fluoroscopic evidence were not available to clarify the state of the neck before nailing, although the initial radiographs appeared normal.

Preoperative CT scans, intraoperative fluoroscopic findings, and postoperative CT scans were available for eight patients (Table I). Six of these eight fractures had been missed at the initial diagnosis.

In two patients (cases 1 and 4), the fracture became visible on abdominal CT scans when the window was changed to bone level. In case 1 the fracture was not diagnosed and fixed until one month after shaft nailing, and healed in a varus position due to this delay (Fig. 2). In case 4, an undisplaced neck fracture was associated with frac-

tures of the intertrochanteric region and the shaft which had been managed by a reconstruction nail. The fracture of the neck was recognised only on retrospective review of an abdominal CT scan (Fig. 3).

In two patients (cases 2 and 6), neck fractures were found on pelvic CT scans taken to evaluate acetabular fractures on the opposite side. Since the pelvic CT scans used a bone level, the neck fractures were diagnosed without difficulty. Case 2 has been discussed above (see Fig. 1); case 6 had some injury to the trabecular system of the left proximal femur and displacement occurred at this level during nailing. The neck fracture was missed on the routine postoperative pelvic radiograph, but detected on a CT scan taken one month later. The fracture was scarcely visible on a coned radiograph of the hip taken in internal rotation (Fig. 4) after the postoperative CT scan.

One missed fracture (case 3) was confirmed by intraoperative fluoroscopy. An undisplaced fracture of the femoral neck had been suspected and became slightly displaced

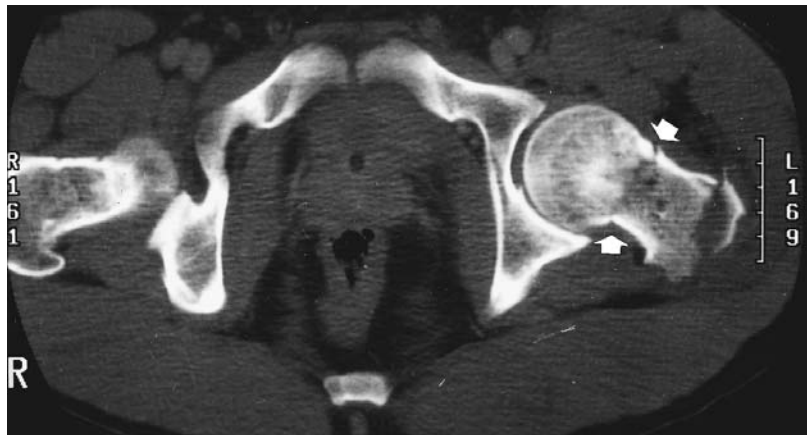


Fig. 3

Case 4. An undisplaced fracture of the femoral neck (arrows) was seen on retrospective review of an abdominal CT scan at bone level, taken before nailing of an intertrochanteric and shaft fracture.

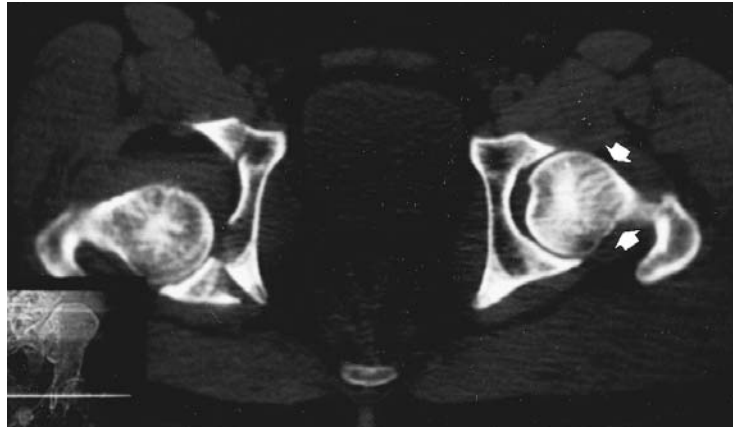


Fig. 4a

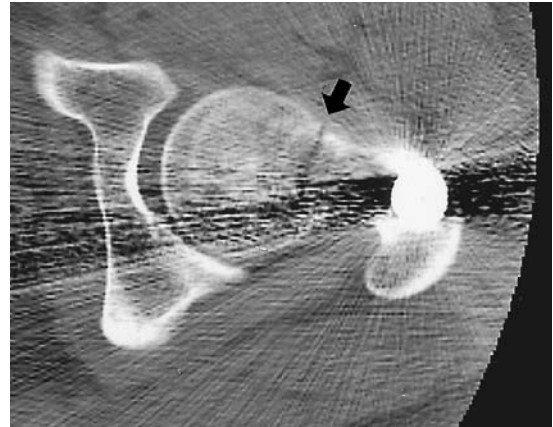


Fig. 4b

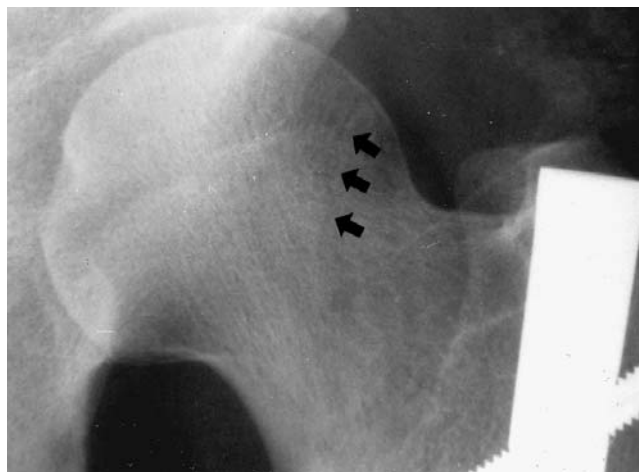


Fig. 4c

Case 6. A CT scan of the pelvis taken to evaluate an acetabular fracture on the opposite side, shows an undisplaced fracture of the left femoral neck, by a void and distortion in the trabecular pattern (arrows) compared with the right side. This fracture was more obvious after nailing (b, arrow). A coned radiograph in internal rotation shows a barely visible fracture of the femoral neck (c, arrows).

during reaming. It was fixed by three Knowles pins after nailing.

One fracture (case 7) was found on a CT scan taken for our prospective study. The shaft fracture was associated with an ipsilateral fracture of the greater trochanter, and the CT scan showed an undisplaced fracture line from the greater trochanter to the base of the neck. The fracture became slightly displaced during nailing of the shaft.

Two of the eight fractures (cases 5 and 8) were therefore considered to be iatrogenic. In case 5, the neck fracture was recognised on the postoperative pelvic radiograph as a vertical defect from the lateral aspect of the subcapital area to the medial side of the base of the femoral neck. Retrospective review of an abdominal CT scan adjusted to bone level showed no fracture. In case 8, the fracture was seen on intraoperative fluoroscopy after the insertion of the



Fig. 5

Case 8. An iatrogenic fracture of the femoral neck after nailing (arrowheads) from the tip of greater trochanter. The proximal part of the nail had been bent to fit the medullary canal.

femoral nail. A CT scan of the neck taken before nailing showed no evidence of injury. This fracture ran from the entry point of the nail at the tip of the greater trochanter, to the base of the neck. In both cases, the entry point was the tip of the greater trochanter and the proximal nail had been bent to fit the medullary canal better (Fig. 5).

All eight shaft fractures had resulted from high-energy motor-vehicle accidents and were in the middle third with varying comminution. All had united uneventfully at a mean follow-up of 16 months (6 to 30), with no evidence of avascular necrosis of the femoral head. There was malunion of the femoral neck in case 1 (Fig. 2d). There were ten fractures of the acetabulum in association with the fractures of the femoral shaft, and three also showed ipsilateral fractures of the neck (one displaced and two missed). Shaft fractures were associated with injuries to the distal femur or the patella or both in 15 patients, and three of them also had ipsilateral fractures of the neck (two displaced and one missed).

Discussion

Delaney and Street⁶ first described the combination of ipsilateral fractures of the neck and shaft of the femur. It is clear that the neck fracture is often missed at the initial assessment, with from 19% to 50% of associated neck fractures diagnosed after fixation of the fractured shaft; the use of closed intramedullary nailing complicates this situation.^{2,4-11} A neck fracture may be diagnosed immediately after nailing or several days later, when mobilisation starts,¹¹ and several cases have been reported as iatrogenic fractures.¹⁴⁻¹⁶ The faulty introduction of a femoral nail may

cause an iatrogenic fracture of the femoral neck, but many so described are probably due to disturbance of an undisplaced fracture during nailing.

A CT scan taken before operation is a sensitive means of detecting such fractures¹⁸ and may account for the relatively high incidence seen in our study. We used postoperative CT scans to discover fracture patterns for the purpose of our study and we do not recommend their routine use. A coned postoperative radiograph of the hip in 15° of internal rotation is usually sufficient unless there is doubt about a possible undisplaced fracture as shown in our case 6.^{2,12}

The presence of associated acetabular fractures, or fracture of the distal femur or patella, all due to longitudinal impacts on the femur^{12,18}, may justify careful study of the neck by CT.

We recommend that CT scans of the pelvis be obtained for patients with multiple injuries and a fracture of the shaft of the femur. In these cases a CT scan of the abdomen is often needed to assess soft-tissue injuries, and a few additional cuts through the pelvis are easily obtained to allow the neck of the femur to be examined using a bone setting.^{2,13} Fluoroscopic examination of the femoral neck is needed if CT is not available, to allow a full assessment of the fractures before operation.^{1,8} MRI is a sensitive investigation for the detection of occult fracture of the femoral neck in elderly patients,¹⁹ but is less practical in patients with multiple injuries.

We recommend the use of a preoperative CT scan of the femoral neck in high-risk patients, with fluoroscopic examination before and after shaft nailing to allow prompt diagnosis and fixation of a fracture of the neck. Routine pelvic radiographs cannot reliably detect undisplaced fractures.

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