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Complex Femoral Fractures - An Analysis

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I. Introduction

Complex fractures of femur often difficult to treat. When the intermediate fragment is split or either level of the fracture is comminuted, the stability offered by most implants is compromised. Conventional closed intramedullary nailing does not provide adequate fixation when cortical contact of the major fragments of the fracture cannot be achieved. Plating of segmental femoral shaft fractures is also an option, particularly when associated with peritrochanteric fractures, but associated with periosteal stripping, increased blood loss, increased operating room time and increased chance of infection. Although technically difficult, intramedullary nailing has been recommended by several investigators and has demonstrated good results. The purpose of this review was to analyse our results with the interlocked nailing of complex fractures of the femur.When electing intramedullary nailing, care must be taken for proper nail selection. Standard interlocking intramedullary nails may be used successfully for fractures that are distal to the lesser trochanter, however, this may require leaving the nail "Proud" to ensure proximal fixation. Cephalomedullary nails are required for fractures that are proximal to the lesser trochanter.

II. Materials and Methods

Between January 2008 and January 2014, 21 patients who had a complex fracture of the femur who were seen at Sri Ramachandra Medical College and Research Institute, Chennai and treated with interlock intramedullary nailing. Data on clinical and radiographic follow-up to the time of union or non-union of the fracture were available for all the patients.Complex fracture can be characterized by the position of the segmental component:

I. Purely diaphyseal intercalary segment: 9 cases.
II. Subtrochanteric-diaphyseal intercalary segment: 8 cases.
III. Diaphyseal-supracondylar intercalary segment: 4 cases.

Intercalary fracture fragment:

A. Simple intercalary fragment. Type IA/5 /IIA/6 IIIA/3
B. Comminuted intercalary fragment. IB-4/ II B 2/ III B/1

There were 18 male and 3 female patients, and the average age was 39 years. High-energy trauma secondary to a motor-vehicle or motorcycle accident or to being struck by an automobile while walking accounted for 85 per cent of the fractures. Major associated injuries were sustained by more than one third of the patients. There were 18 closed and 3 pts had Grade I open fractures. The average time to nailing after fracture was 3 days (range 0 to 12 days).

Interlocked nailing was performed, on the basis of the location and the degree of comminution of the fracture. For diaphyseal intercalary segment standard static interlocked nailing was done using 2 screws inserted proximal and distal to the fracture. In Subtrochanteric-diaphyseal intercalary segment, when the fracture extends to a trochanteric or subtrochanteric area, we have used Cephalomedullary nail (RECON or SIRUS) to have purchased in the femoral head and neck for better rotational and angular stability. In Diaphyseal-supracondylar intercalary segment, we have used a nail which has got 3 or 4 interlocking options distally in 2 planes (SIRUS NAIL).

All nailings were performed under C-arm control with use of fracture table. In 2 patients in whom closed reduction of one or both fractures was unsuccessful and open reduction was needed, the fascia was closed after passage of the guide-pin, and the remainder of the procedure, including reaming and insertion of the nails, was performed under C-arm control. Postoperatively, the patients were allowed six weeks of partial weight-bearing with walker support, followed by progressive weight-bearing as tolerated.

The time to union of the fracture was defined as the time from injury to full weight-bearing and healing of the fracture, with healing characterized by bridging callus seen on two radiographs made with different

projections. Union was considered delayed if there was absence of healing as assessed on standard radiographs nine months after injury; non-union was considered to be present if there was pain at either site of fracture, continued need for external support, and no radiographic evidence of healing at one year after injury; and malunion was defined as shortening or lengthening of more than one centimeter, 10 degrees or more of angulation in any plane, or rotational malalignment of more than 15 degrees.

III. Results

The duration of follow-up ranged from 6 to 72 months (average 36 months). Closed nailing was accomplished in 90 (19 cases) per cent of the patients. In the remaining 10 per cent (2 patients), open reduction was necessary because of failure to pass the guide-wire across a site of fracture under fluoroscopic control. The average intraoperative loss of blood was 189 millilitres. The operating time, including positioning of the patient on the fracture-table, averaged 173 minutes.18 fractures united without additional intervention. The average time to union of both segments of the fracture was 28 weeks (range 12 to 60 weeks).

One deep infection managed with two weeks of IV antibiotics followed by four weeks of oral antibiotics. No patient developed fat embolism in this series.Two patients had non-union. The one non-union was in a purely diaphyseal intercalary segment group, patient underwent bone grafting at 5 months following which fracture united. The other patient in a intertrochanteric diaphyseal intercalary segment group where diaphyseal segment united but intertrochanteric segment failed to unite after one year IM nail removal done, un-united intertrochanteric segment has been fixed with DHS and bone grafting.

7 patients had less than 60 degrees of flexion of the knee. Of which 4 patients had ipsilateral tibial condyle fractures. 3 patients knee ROM increased with physiotherapy to 90 degrees. 2 patients underwent manipulation of knee to improve knee flexion to 100 degrees. 1 patient had resulted in both intra and extra-articular stiffness with arthritic changes of knee later underwent TKR, had knee ROM of 90 degrees. One patient had FFD of 15 degrees had further flexion of 30 degrees with shortening of 5 cms. One patient had delayed union in a subtrochanteric diaphyseal intercalary segment group distal segment united, but the proximal segment showed delayed union, patient underwent bone grafting at 3 months and dynamisation at 5 months.

IV. Discussion

Internal fixation of complex fractures of the femur has gained widespread acceptance in the past decade as implants and technology have improved. The rationale for internal fixation is that it restores anatomical alignment and allows early mobilization of the patient and the limb. However, stable internal fixation has been difficult to achieve. The use of a plate to achieve osteo-synthesis of segmental fractures necessitates a wide operative exposure and extensive stripping of soft tissue, resulting in increased loss of blood and a longer operating time. The risk of infection is increased, failure of the plate is common, and the need for primary bone graft adds additional morbidity to the procedure. Due to the high rate of complications associated with this type of fixation, most traumtologists have advocated intramedullary nailing for complex femoral fractures. Conventional closed Kuntscher nailing eliminates unsightly scarring of the thigh, minimizes disruption of the soft tissues at the site of fracture, reduces the risk of infection, and restores anatomical alignment. Unfortunately, in comminuted fractures, an unlocked nail cannot completely maintain the length or rotational alignment of the limb. The use of supplemental cerclage wires or unicortical plates and screws for such comminuted fractures negates the full benefits of closed nailing and does not always provide secure internal fixation.The success of Interlock intramedullary nailing for simple shaft femoral fractures has prompted the surgeons to extend its indications for comminuted and segmental fractures of the femur. But certain intraoperative techniques are essential for the success of these procedures in these complex fractures.

The starting hole is crucial, and care must be taken to ensure that it is within the piriformis fossa or Trochanteric entry and aligned with the long axis of the proximal femur in the AP and lateral fluoroscopic images. A helpful technique, if the fracture pattern allows, is to reduce the segmental component to the proximal fragment and then pass the guidewire in the centre of each fragment using C-arm imaging.Reaming is then undertaken to the appropriate diameter. Several authors have discussed the theoretical risk of spinning the central fragment during reaming, thereby damaging the blood supply and delaying healing. In our experience, the strong attachment of the soft tissues along the linea aspera prevents spinning in most patients. However, when the intermediate fragment is less than ten centimeters in length, spinning is a risk, and reaming should be performed slowly and carefully.

After reaming proximally, the distal fracture is then reduced and the guidewire is passed into the distal fracture fragment. Reaming then is performed in the distal fragment to the same diameter as was done proximally. For fractures with a large comminuted segmental fracture, the guide wire is passed through the proximal and distal intact femur and reaming is undertaken by passing the comminuted injury zone, with care to maintain the reduction.


Fig.1 - X-Ray of Right femur AP and Lateral views showing segmental fracture.


Fig.2 - X-Ray of Right femur AP and Lateral views showing healed fracture after nine months.

Obtaining and maintaining reduction is often difficult without an intact diaphysis to use as a template for reduction. Also, multiple fracture lines often are difficult to align with closed manipulative means. Reduction devices commonly are required to obtain and maintain reductions. Mallets and spiked pushers, found in the pelvic reduction tray, are useful to push fragments into position. Various hooks are also useful if fragments require a pull to obtain the reduction. Schanz pins are frequently beneficial in aligning intercalary fractures and the distal metaphysis during guidewire placement, reaming, and nail placement.

Passage of the nail requires vigilance to maintain an appropriate reduction. Without an intact diaphysis to capture the nail, the nail tends to translate medially. This can be particularly problematic in patients with large buttocks in whom there is difficulty in adducting the proximal nail and jig against the soft tissues, which exacerbates distal medial nail translation. Occasionally, it may be necessary to guide the nail into the distal metaphysis with a percutaneously placed hook. With the introduction of the nail into the distal femoral metaphysis, alignment must be monitored because the nail will have a tendency for eccentric placement leading to fracture malalignment.

Range of Motion

Wiss[1] et al have recorded that the most recent follow-up of the thirty-three patients, the average flexion of knee was 110 degrees. No patient had a flexion contracture of the knee. Two patients had less than 90 degrees of flexion of the knee; one had associated injuries to the ligaments of the knee and the other, a fracture of the ipsilateral tibia.Winquist[5] et al have noted of 20 patients the range of knee motion averaged 135 degrees. Three patients had mild chondromalacia.Church[7] et al showed that stiffness of the knee was a common sequela of this fracture type.

In this series 7 patients had less than 60 degrees of flexion of the knee. Of which 4 patients had ipsilateral tibial fractures. 3 patients knee ROM increased with physiotherapy to 90 degrees. 2 patients underwent manipulation of knee to improve knee flexion to 100 degrees. 1 patient had resulted in both intra and extra-articular stiffness with arthritic changes of knee later underwent TKR, had knee ROM of 90 degrees. One patient had FFD of 15 degrees had further flexion of 30 degrees haven't improved further.

Shortening

Wiss[1] et al stated that in one patient, four millimetres of shortening at the fracture occurred after dynamisation, but it was not associated with any functional.Winquist[5] et al recorded that in six patients shortening of between 1.0 and 1.5 centimetres occurred. This degree of shortening did not prove symptomatic for any of these patients. Unfortunately, when comminution exists at either fracture level, shortening cannot be prevented when a weight-bearing intramedullary nail is used.

Kempf and Grossee[22] reported 11 cases of shortening among 52 patients with comminuted femur shaft fractures treated by interlocking nailing.Thoresen[23] et al reported 6 cases of shortening in 48 patients with femur shaft fractures treated by interlocking nailing.In this series shortening of between 0.5 cm and 5 cm occurred is a case of 7 patients.

Malunion

Wiss[1] et al reported there were two malunions: one in a patient who had a varus angulation of 15 degrees and the other in a patient who had a lengthening of eighteen millimetres.Winquist[5] et al observed valgus deformity in four patients, measuring 3, 5, 6 and 11 degrees. Five patients were treated with a cylinder cast or a cast-brace for four to six weeks to prevent this deformity, but in one of them – a fifty-nine year old woman -- this treatment was unsuccessful and 11 degrees of angulation developed at the distal fracture site. None of these valgus deformities proved symptomatic. Three degrees of varus angulation were noted in one patient and 5 degrees of genurecurvatum, in another. Although these complications (minor malunion) were recorded, all were asymptomatic for the patients.

Donaldwiss[18] et al reported varus / valgus angulation in 14 patients out of 112 unstable comminuted femoral shaft fractures.Kempf and Grosse[22] reported 8 cases of varus angulation in 52 patients.In this series 8 patients had malunion, one patient who had a Coxavara of 90 degrees at the proximal trochanteric region because of faulty entry point with shortening of 5 cm, patient refused for further corrective procedures. Shoe heel raise of 5 cm given. Five valgus deformity of 10, 10, 11, 13, 13 degrees and varus deformity of 12, 14 degrees were noted. Although these complications were recorded, these were asymptomatic for the patients.

Delayed union and Dynamisation

Wiss[1] et al reported one delayed union, dynamisation of static interlocked nailing by removal of either the proximal or distal screws was not routinely performed unless there was a suspected delay in healing of the fracture. Dynamisation was performed in only nine of the twenty-eight patients. The average time to dynamisation was 18.2 weeks. There was no major difference in the rate of healing of the fracture with the use of static compared with dynamic interlocked nailing.Brumback[37] et al reported 2 cases of delayed union out of 100 femoral shaft fractures which subsequently healed after dynamisation. They concluded that conversion to dynamic fixation is rarely necessary after static inter locking.

The need for dynamisation of statically locked femoral shaft fractures is still controversial. Grosse and Kempf recommended routine conversion to dynamic fixation at 10 to 12 weeks after static nailing. Shortening after dynamisation was reported in some of these patients, in whom the comminuted femoral fracture was not sufficiently healed to resist axial loading.In this series 1 patient had delayed union in a subtrochanteric diaphyseal intercalary segment group distal segment united, but the proximal segment showed delayed union, patient underwent bone grafting at 3 months and dynamisation at 5 months.

Non-union

Wiss[1] et al reported one non-union in his series in a patient who had an open fracture where closed distal segment healed, but the open proximal portion failed to unite. At nine months, the nail broke at the site of non-union. The implant was removed through the entrance portal of the greater trochanter, and the fracture was nailed again. It healed uneventfully within four months.Kempf and Grosse[22] reported 5 cases of non union (4 aseptic and 1 septic) in 52 patients. 4 cases of aseptic non-union healed after exchange locked intramedullary nailing without bone grafting.

In this series 2 patients had non-union. The one non-union was in a purely diaphyseal intercalary segment group, patient underwent bone grafting at 5 months following which united. The other patient in an intertrochanteric diaphyseal intercalary segment group where diaphyseal segment united, but intertrochanteric segment failed to unite after one year IM nail removal done, un-united intertrochanteric segment has been fixed with DHS a bone grafting.

V. Conclusion

Virtually all fractures distal to the trochanter and proximal to condyles can be nailed, regardless of the pattern of the fracture or the degree of comminution

1) Careful preoperative planning, intraoperative techniques and strict postoperative protocols are necessary for a successful outcome of these complex fractures.
2) We have got 9 Excellent, 7 Good, 4 Fair and 1 Poor result in this series.
3) We recommend

a. Standard interlock intramedullary nails with 2 screws proximally and distally in diaphyseal intercalary segment fractures
b. Cephalomedullary nails for fractures with trochanteric or subtrochanteric extension
c. Nails with 3 or 4 distal locking options in 2 different planes for the diaphyseal supracondylar type of fracture.

Comparative Study

	WISS et al	**WINQUIST et al**	**This Series**
No. of cases studied	33	20	21
Male / Female	25/8	12/8	18/3
High energy trauma	28	19	17
Closed / Open fracture	28/5	14/6	18/3
Average age	31 yrs	38 yrs	39 yrs
Associated injuries	60%	48%	52%
Average time of nailing	9 days	-	3 days
Operating position Supine / Lateral	32/1	20/0	18/3
Average operating time	157 mins	95 mins	173 mins
Additional intervention for fracture union	27%	-	14%
Supplemental external support after nailing	-	35%	5%
Average fracture union	32 weeks	30 weeks	28 weeks
Average blood loss	470 ml	-	189 ml
Closed reduction / Open reduction	90% (Closed reduction) 10% (Open reduction)	Closed reduction in all patients	90% (Closed reduction) 10% (Open reduction)
Complication			
Non-union	3%	-	9%
Delayed union	3%	-	5%
Malunion	6%	30%	39%
Knee stiffness	6%	-	33%
Shortening	3%	30%	33%
ARDS prior to nailing	-	35%	5%
Average follow-up	14.5 months	41 months	36 months
Average ROM			
Knee	110^{o}	135^{o}	105^{o}
Hip	115^{o}	-	110^{o}

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