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A Prospective Study on Functional Outcome of Double Plating for Distal Femur Fracture

[1]Praveen Narayan, [2]B. Raghunath Reddy and [3]Pothuri Rishi Ram

[1]Department of Advanced Orthopaedic Trauma, Sanjay Gandhi Institute of Trauma and Orthopaedics

[2]Department of Advanced Orthopaedic Trauma, Sanjay Gandhi Institute of Trauma and Orthopaedics

[3]Department of Sports Injury and Arthroscopy, Sanjay Gandhi Institute of Trauma and Orthopaedics

ABSTRACT

Fractures within 15cm from articular surface of distal femur i.e., between articular surface and junction of metaphysis to femoral diaphysis are defined as distal femoral fractures which constitute around 5-6% of femoral fractures. Lateral locking plates are now the choice of internal fixation and have replaced common blade plate in distal femur fractures. When there is short distal fragment and metaphyseal comminution with defect in medial cortex, chances of varus collapse due to increased bending tendency caused by vertical load are common in internal fixation of distal femur fracture with single lateral locking plate alone. So additional support of distal femur fracture stabilization by using double-plating technique similar to that used in two column fractures of acetabulum, distal humerus and tibial plateau has been done in this study, based on failed cases encountered with single lateral plating in the past and literature support on double plating of distal femur fractures. This study was conducted at Sanjay Gandhi Institute of Trauma and orthopaedics, involving 20 cases. The participants included Muller type A2, A3 and type C2, C3 distal femur fractures, Simple and compound grade I Gustilo and Anderson fractures. Compound grade II and III fracture and Muller type A1, type B1, B2, B3 and type C1 distal femur fractures cases were excluded. Follow up assessments were conducted at 4 weeks, 8 weeks and thereafter every 3 months utilizing American knee society scoring system. Overall results were excellent in 5 out of 20 cases and were good in 8 cases. The outcome was fair in 5 cases and poor in 2 cases. Knee score of 70 and above is considered as good and in our study 13 out of 20 patients had a score more than 70 and remaining 7 patients had fair and poor results. The overall mean score in our study was 73.4 units. 6 of 20 cases had complications in our study with 4 cases resulting in knee stiffness. 1 case had implant loosening because of osteoporotic nature of the bone. 1 case resulted in chronic infection. In our study though there were complications and increase in operating time, the union rate is 100% with no varus deformity or malunion and functional range of movements were good in 40% of cases and excellent in 25% cases, so double plating is one of the better option to achieve bony union and better functional outcome in severely comminuted distal femur fractures.

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Key Words

Distal femur fracture, double plate, lateral approach, medial approach

Corresponding Author

Pothuri Rishi Ram,

Department of Sports Injury and Arthroscopy, Sanjay Gandhi Institute of Trauma and Orthopaedics

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INTRODUCTION

Fractures within 15 cm from articular surface of distal femur i.e., between articular surface and junction of metaphysis to femoral diaphysis are defined as distal femoral fractures which constitute around 5-6% of femoral fractures. These fractures are frequently associated with high velocity trauma, comminution, soft tissue injury, instability and articular surface extension. Anatomical reconstruction of articular surface, restoring rotational and axial alignment, stable fixation, early mobilization and functional rehabilitation are main goals of surgical treatment[1].

Before 1970's, majority of distal femoral fractures were managed conservatively with traction resulting in prolonged confinement to bed with complications of recumbency. Poor anatomical reduction, loss of knee motion led to improvement in methods of treatment. Management of distal femoral fractures had changed from treating nonoperatively to open reduction and internal fixation of displaced distal femoral fractures due to improved operative techniques and implants[2].

Lateral locking plates are now the choice of internal fixation and have replaced common blade plate in distal femur fractures. Retrograde nails were recently developed with more stability and better biomechanical performance for distal femur fractures not having much condylar comminution. Common association of distal femur fractures with diabetes, open fractures and infection resulted in delayed fracture union, malunion and proximal implant failure commonly varus collapse[3].

Muscular forces acting on distal femur, weight bearing and gravity all affects fracture stabilization. When there is short distal fragment and metaphyseal comminution with defect in medial cortex, chances of varus collapse due to increased bending tendency caused by vertical load are common in internal fixation of distal femur fracture with single lateral locking plate alone[4].

So additional support of distal femur fracture stabilization by using double-plating technique similar to that used in two column fractures of acetabulum, distal humerus and tibial plateau has been done in this study, based on failed cases encountered with single lateral plating in the past and literature support on double plating of distal femur fractures[5].

Aims and objectives: To find the functional outcome of double plating for the distal femur fractures using condylar locking compression plate through lateral approach and buttress plate using medial subvastus approach.

Objectives:

- To investigate the clinical, radiological and functional outcome in patients treated by double plating technique for comminuted distal femur fractures
- To analyze the influence of age, sex, mechanism of injury, fracture type, operative time and associated injuries in the final functional outcome

MATERIALS AND METHODS

Study venue: Department of Orthopaedics, Sanjay Gandhi Institute of Trauma and Orthopaedics, Bangalore

Study design: Prospective study.

Study period: November 2020-2022

Sample size: Twenty patients

Inclusion and exclusion criteria

Inclusion criteria:

- Age between 20 and 50 years
- Fractures less than 2 weeks
- Simple and compound grade I fractures (Gustilo and Anderson classification)
- Muller type A2, A3 and type C2, C3 distal femur fractures

Exclusion criteria:

- Age less than 20 years and more than 50 years
- Compound grade II and III fracture
- Muller type A1, type B1, B2, B3 and type C1 distal femur fractures
- Associated with distal neurovascular deficit
- Systemic conditions such as osteoarthritis, malignancy, immunocompromised states

Preoperative planning: Patient will undergo a pre-operative evaluation:

- **Clinical examination:** Palpation revealed abnormal mobility and crepitus. Distal vascularity was assessed by anterior and posterior tibial artery pulsations, capillary filling, pallor and paresthesia at tip of toes
- **Baseline investigations:** Radiograph-x-ray thigh with knee AP, lateral and oblique views, CT femur with knee with 3D reconstruction
- Primarily immobilization of the fracture done with upper tibial pin traction.
- Informed consent from the patient
- Anesthesia-regional anesthesia

Operative procedure

Lateral fixation:

- Placing the patient supine and a roll under the knee

- A midline incision made from above the fracture laterally to across the patella (Swashbuckler approach)
- The incision extended directly down to the fascia of the quadriceps. Quadriceps fascia incised and sharply dissected off the vastus lateralis muscle laterally to its inclusion with the iliotibial band (Fig. 1)
- Iliotibial band and fascia retracted laterally, continuing the dissection down to the linea aspera
- Lateral para patellar retinaculum incised, separating it from the vastus lateralis
- Lateral para patellar arthrotomy done to expose the femoral condyles
- Plate is placed in a sub muscular fashion on the reconstructed condyles and fixed with locking screws

Medial fixation:

- After lateral fixation, medial fixation through medial approach proceeded
- An anteromedial incision from anterior margin of pes anserinus following the adductor canal, then fascial envelope surrounding the vastus medialis incised along the posterior margin of the muscle
- Blunt dissection done to elevate the muscle off the periosteum and the intermuscular septum from adductor tubercle to intact proximal femur shaft
- Distally vastus medialis tendinous insertion incised 2-3 cm wide into the medial capsule. Then the joint exposed through medial Para patellar arthrotomy
- Now the medial plate is placed after reduction found satisfactory and fixed using screws with traverse portion placed distally
- Thorough wound wash given and wound closed in layers (Fig. 2).

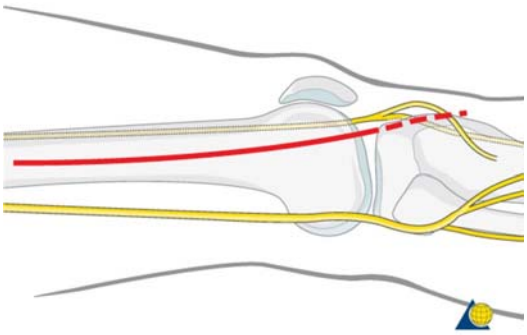


Fig. 1: Lateral fixation

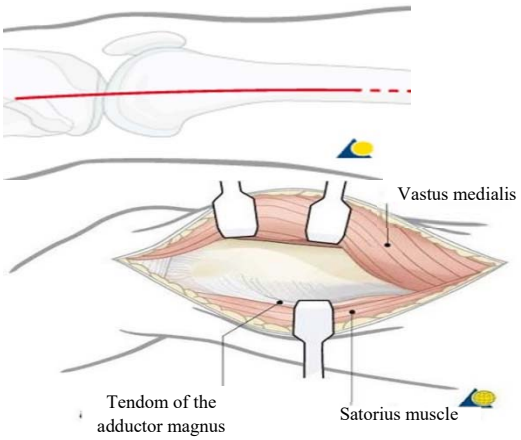


Fig. 2: Medial fixation

Patient position

MIPO incision lateral side

Plate fixation by MIPO

Plate fixation by open reduction

Fig. 3: Continue

Fig. 3: Surgical procedure

Post operative protocol:

- 1st EOT - 2nd POD
- 2nd, 3rd EOT-5th, 8th POD
- Suture removal-10-12th POD
- Continuous passive mobilization exercises with range of motion started at 30 degrees and then advanced on daily basis
- Non weight-bearing using walker after 2 weeks
- Partial weight-bearing using underarm crutches after 6 weeks
- Full weight-bearing after radiological evidence of bony union (minimum of 12 weeks postoperatively)

Follow-up: Patients were advised to report for follow up at 4 weeks, 8 weeks and thereafter every 3 months. At every follow up a detailed clinical examination was done, patients were assessed subjectively for the symptoms like pain, swelling and restriction of joint movements. Patients were on physiotherapy in the form of active flexion and extension exercises without loading.

Functional assessment: The functional assessment of the patient was done according to American knee society scoring system (Table 1).

Grading of results:

- Score 80-100 = Excellent
- Score 70-79 = Good
- Score 60-69 = Fair
- Score below 60 = Poor

Table 1: Functional assessment

Pain	Points
None	50
Mild or occasional	45
Stairs only	40
Walking and stairs	30
Moderate	
occasional	20
continual	10
sever	0
Range of motion	
5° = 1 Point	25
stability	
Anteroposterior	
<5mm	10
5-10	5
10mm	0
Mediolateral	
<5°	15
6-9°	10
10-14°	5
>15	0
Subtotal	[-]
Deductions points (minus)	
Flexion contracture	
5-10°	2
10-15°	5
16-20°	10
>20°	15
Alignment	
5-10°	0
0-4	3 points each degree
11-15	3 points each degree
other	20
Total deductions	[-]
Total knee score	[-]

Statistical analysis

Age incidence: In this study patients are from second, third and fourth decade. Mean age in this group was 36.1 (Table 2).

Sex incidence: In this study 80% of the cases were male patients and 20% were female patients. This

shows high incidence of distal femur fractures in male patients since most outdoor activities and susceptibility to trauma were male when compared to female (Table 3).

Side of injury: In this study left lower limb is involved slightly more but there is no significant difference in side of injury (Table 4).

Fracture distribution according to type: Five percent of Muller type A2 cases, 20% with type A3, 45% with type C2 and 30% type C3 fractures included in this study (Table 5).

Associated injuries: Associated injuries mostly involve ipsilateral lower limb injuries including ligamentous injuries of knee joint since most cases are due to road traffic accidents. Many poly trauma patients had upper limb injuries, opposite side lower limb injuries, associated multisystem involvement like multiple rib fractures, hemothorax and head injury (Table 6).

Operative time: Time taken for a surgery varies from less than 120-210 min per surgery. 55% of cases took more than 150 minto complete the surgery (Table 7).

7 cases are indexed below:

- Cases 1 to 3: had excellent results
- Case 4: had a good result
- Cases 5 to 7: with complications

CASE 1:

- Age/Sex: 36 /Male
- Mode of Injury: RTA
- Side: Right
- Associated Injury: Fracture both bone right leg, patella
- Right (comminuted) compound grade I
- Associated Comorbidity: No
- Muller's type: Closed Type CII Fracture
- Time Interval for Surgery: 8 days
- Operative time: 210 Min
- Time for radiological union: 24 weeks
- Knee flexion achieved: 95°
- American Knee society score: 86
- Complications: NIL
- Functional outcome: Excellent

Table 2: Age distribution

Age	No. of patients	Percentage
21-30	6	30
31-40	8	40
41-50	6	30
Total	20	100
Mean	36.1	
SD	8.391	

Table 3: Gender distribution

SEX	No. of Patients	Percentage
MALE	16	80
FEMALE	4	20
TOTAL	20	100

Table 4: Side involved

Side Involved	No. of Patients	Percentage
Left	11	55
Right	9	45
TOTAL	20	100

Table 5: Fracture

Fracture Type	No. of Patients	Percentage
A2	1	5
A3	4	20
C2	9	45
C3	6	30
TOTAL	20	100

Table 6: Associated injuries

Associated Injuries	No. of Patients	Percentage
Chest Injuries	1	5
Head Injuries	1	5
Opposite side lower limb Injuries	1	5
Same side lower limb injuries including Ligament injuries	4	20
Upper Limb Injuries	1	5
Nil	12	60
TOTAL	20	100

Table 7: Operative time in minutes

Operative Time in Mins	No. of Patients	Percentage
< 150	9	45
> 150	11	55
TOTAL	20	100

Pre OP X-Ray

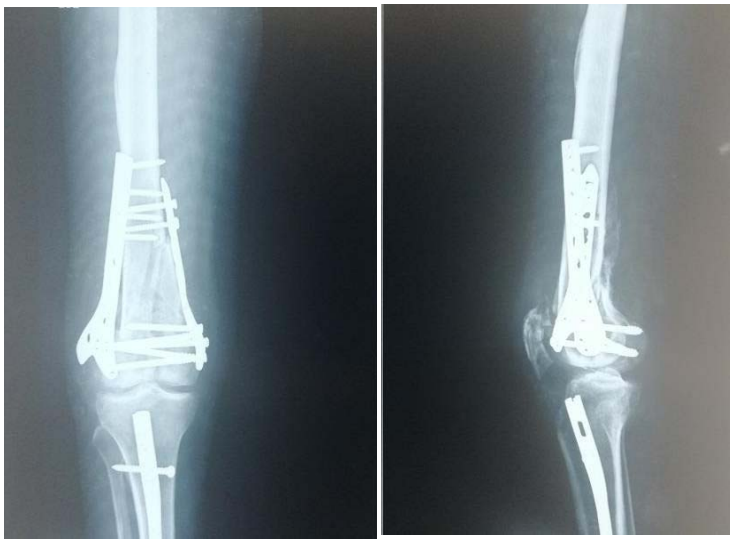
AP view Lateral view AP view

CT Knee image

Immediate post OP X-Ray

AP view Laternal vies AP view

1 month post op x-ray



1 month follow up clinical picture


6 month post op x-ray


AP view


Lateral view

6 month post op clinical picture


Flexion


Extension

Case 2:

- Age/Sex: 48 /Male
- Mode of Injury: RTA
- Side: Left
- Associated Injury: Operated with Lateral Plating Alone 2
  Months back for distal femur fracture, now with peri-implant fracture due to varus collapse
- Associated comorbidity: No
- Muller's type: Closed type ciii fracture
- Time Interval for Surgery: 5 days
- Operative time: 120 min
- Time for radiological union: 20 weeks knee
- Flexion achieved: 105^{o}
- American Knee society score: 90 Complications: NIL
- Functional outcome: Excellent

Post op x-ray after surgery

Varus collapse 1ST in 2 months

Immediate post op X-Ray

3rd month post op X-ray

5th month post op X-ray

5th month clinical picture

Flexion

Extension

CASE 3:

- Age/Sex: 50/Female
- Mode of injury: RTA
- Side: RIGHT
- Associated Injury: NIL
- Associated comorbidity: NIL
- Muller's Type: Closed type CII Fracture
- Time interval for surgery: 3 days
- Operative Time: 120 MINS
- Time for radiological union: 24 weeks Knee
- Flexion Achieved: 95° American
- Knee society score: 64
- Complications: Implant failure
- Functional outcome: Fair

Pre op x-ray

Immediate post op x-ray

1st month post op x-ray

AP view

1st month follow up clinical picture

Flexion

Extension

3rd month post op x-ray

3rd month follow up clinic

Case 4:

- Age/Sex: 40 /Male
- Mode of Injury: RTA
- Side: LEFT
- Associated Injury: NIL
- Associated Comorbidity: NIL
- Muller's Type: Closed Type CIII Fracture
- Time Interval for Surgery : 7 days
- Operative Time: 150 MINS Time
- For Radiological Union: 24 weeks Knee
- Flexion Achieved: 95°
- American Knee society score66
- Complications: Infection
- Functional outcome: Fair

Pre op x-ray

Post op x-ray

1st month follow up clinical picture

Flexion

Extension

1 year follow up post op Xray

1 year follow up clinical picture

OBSERVATION AND RESULTS

Overall results were excellent in 5 out of 20 cases and were good in 8 cases. The outcome was fair in 5 cases and poor in 2 cases (Table 8).

Knee score of 70 and above is considered as good and in our study 13 out of 20 patients had a score more than 70 and remaining 7 patients had fair and poor results. The overall mean score in our study was 73.4 units (Table 9).

Goals of rehabilitation:

- About 65°-70° flexion is required for swing phase of gait
- About 90° flexion is required to ascend and descend the stairs
- About 105º flexion is required to rise early from a low chair

In this study only 2 out of 20 patients had a range of motion less than 70°, 2 patients had flexion upto 70°, 2 patients between 70° to 90° of maximum flexion and 14 patients had 90° or more of flexion (Table 10).

Average healing time both clinically and radiologically varies from 18 weeks to 24 weeks in our study with a mean healing time of 20.9 weeks and 11 out of 20 cases healed both clinically and radiologically within 20 weeks (Table 11).

In our study there was 4 female patients out of 20 cases in which 2 female patients had good results none had an excellent result, 1 had a fair result and 1 female patient had a poor result. Among 16 male cases, 5 had excellent results and 6 had good results, 4 had a fair result and 1 had a poor result (Table 12)

In our study two patients had poorer result, one is of Muller type C2 and the other type C3. Muller type A2 and A3 had relatively good results compared to intra articular severely comminuted C3 type fractures. Results are comparatively good in simple fracture patterns (Muller type A2 and C2) than severely comminuted fractures (A3 and C3) (Table 13).

6 of 20 cases had complications in our study with 4 cases resulting in knee stiffness of which 2 patients had severe knee stiffness. Besides CPM and physiotherapy, they could not achieve more than 50 degree of knee flexion. Remaining 2 patients achieved reasonable flexion upto 70 degrees with CPM and physiotherapy.

1 case had implant loosening because of osteoporotic nature of the bone in that individual. Non-locking screw of medial buttress plate had pulled out and formed an infected bursa. Screw was taken out with small incision at the end of 3 months.

Table 8: Score results

Score Result	No. of patients	Percentage
Excellent	5	25
Good	8	40
Fair	5	25
Poor	2	10
TOTAL	20	100

Table 10: Range of motion

Range of motion	No. of patients	Percentage
0 to 30	1	5
0 to 50	1	5
0 to 70	2	10
0 to 80	2	10
0 to 90	4	20
0 to 100	7	35
0 to 110	2	10
0 to 120	1	5
Total	20	100

Table 11: Healing time

	Healing time			
	Clinical	Percentage	Radiological	Percentage
<20	11	55	11	55
>20	9	45	9	45
Total	20	100	0	0

Table 12: Sex vs score result

	Sex vs score result			
	Excellent	Good	Fair	Poor
Male	5	6	4	1
Female	0	2	1	1
Total	5	8	5	2

p-value, 0.599, Not significant

Table 13: Fracture type vs score result

	Fracture type vs score result			
	Excellent	Good	Fair	Poor
A2	0	1	0	0
A3	0	3	1	0
C2	4	3	1	1
C3	1	1	3	1
Total	5	8	5	2

p-value 0.412, Not significant

Table 14: Complications

Complications	No. of Patients	Percentage
Implant loosening	1	5
Infection	1	5
Knee stiffness	4	20
Nil	14	70
Total	20	100

1 case resulted in chronic infection. Infected case was treated with parenteral antibiotic after identifying the organism. Patient had union at the end of 6 months and functional outcome was fair. Implant exit was done for that patient at the end of 1 year (Table 14).

DISCUSSIONS

Treatments of distal femoral fractures is a cumbersome subject. There have been changing principles towards surgical treatment for supra condylar fractures of femur. Close management of these fractures was the treatment of choice until 1970. This was mainly due to lack of proper techniques and appropriate implants. Conservative methods at any age may be complicated by knee stiffness, malunion and nonunion. Early surgical stabilization will facilitate care of the soft tissue, reduces bedridden period and the complexity of nursing care. Open reduction and internal fixation using angled blade plate, fickle devices, Rush rods, Ender nails, DCS, condylar buttress plate and interlocking nails, locking compression plate.

The conventional plates are associated with demerits such as screw pullout, implant failure and less rigid fixation requiring postoperative immobilization. Locking plate will decrease the screw-plate toggle and also the motion at the bone-screw interface thereby provides more rigid fixation[6].

In cases where fracture fragments in the medial side were severely comminuted or having massive bone defect, single lateral plate fixation may fail to stabilize fracture sites, resulting in knee varus deformity, breaking of plates and screws and nonunion. One such case was included in this study where the patient undergone single lateral fixation for comminuted distal femoral fracture resulted in varus collapse and implant failure after two months of surgery. Implant removal was done and redo surgery with bicolumn plating was done for that patient. At the end of one-year follow-up, patient had bony union with more than 100 degrees of knee flexion. In cases involving single lateral plating, the rates of varus collapse and non-union were high but in our study the addition of medial plating has not yielded any case of varus deformity or malunion[7-12].

Bone grafting either autograft/allograft or bone graft substitutes not done in our study except in one case where cancellous iliac bone autograft was done. In our study the average time taken per patient to complete the surgery is 143 min. Particularly in patients with associated injuries, timing of surgery extends to more than 3 hours for completing surgery, since we have to fix more than one fractures in these patients. Risk of infection and anesthesia complications increase exponentially with increase in operating time.

Muller type A2 and C2 fractures comparatively had a better result compared to type A3 and C3 patients. Even after double plating 3 shattered distal femur fractures of C3 type were on POP for 4 weeks during post-op period in this study due to severe comminution and segmental bone loss. Nail-plate combination technique for stable, balanced fixation allowing immediate weight bearing and early mobilization and Intra-osseous plating technique for cases with intra-articular comminution or segmental bone loss of far (medial) cortex where intramedullary nails cannot be used. These two techniques are promising in improving the quality of life in severely comminuted intra-articular fractures (type C3) patients in future where even double plating is not sufficient to give stable fixation[12-14].

In bicolumn fracture fixation of the distal femur fractures with comminution, the prognosis factors include age, method of treatment, intra articular involvement and timing of joint mobilization, etc. For all these patient early rehabilitation, physiotherapy and aggressive post- operative protocol should be followed for better functional outcome[15,16].

Major contributing factors are:

- Improper fixation may be due to complexity of fracture comminution
- Elderly patient with less motivation to begin exercise and low osteogenic potential
- Delay in surgery causing increase in interval between injury and surgery
- Open/closed fractures

Imam *et al*.[17] did a prospective study on 16 patients with distal femoral fractures of Muller type C3. These patients were treated using dual plating and analyzed the outcomes including clinical and radiological outcomes and postoperative complications. Their results shown 68.75% of the studied patients had good-excellent functional outcome with 68.75% of patients having range of motion (90^{o}-120^{o}) during follow-up. The mean time of radiological union in their study was 6.0+3.5 months with a range of 3-14 months. There is no postoperative varus or valgus deformity in their study[18,19].

Our study also had a similar result with union rate of 100% and average healing time between 18-24 weeks both clinically and radiologically and a mean healing time of 20.9 weeks (5 months) with no cases of varus deformity or malunion. 65% of patients had good-excellent functional outcome in our study with 70% of patients having range of motion more than 90^{o}.

LIMITATIONS OF THE STUDY

Our Study comprises of relatively small number of patients and not a strict random controlled trial design. Repair of injured ligaments of knee joint not done during acute phase along with fracture fixation in our study. Stainless steel plates are used in both medial and lateral sides due to economical constraints which limits the use of MRI for the evaluation of ligament injuries of the joint during follow-up.

CONCLUSION

In our study though there were complications and increase in operating time, the union rate is 100% with no varus deformity or malunion and functional range of movements were good in 40% of cases and excellent in 25% cases, so double plating is one of the better option to achieve bony union and better functional outcome in severely comminuted distal femur fractures.

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