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A CLINICAL STUDY OF DISTAL FEMORAL FRACTURES TREATED BY RETROGRADE FEMORAL NAILING – BIOLOGICAL AND BIOMECHANICAL ADVANTAGES WITH REVIEW OF LITERATURE

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Abstract:

Background: Distal femoral fractures with or without intra-articular extension are often difficult to treat as they are usually associated with a high incidence of complications like knee stiffness, quadriceps wasting, knee instability, mal-union, non-union, joint incongruity, shortening and osteoarthritis. The management of these fractures by retrograde femoral nailing has the advantages of preservation of fracture hematoma, decreased blood loss, minimal soft tissue dissection, early mobilization and less post-operative complications. The present study aims to evaluate the results of distal femoral fractures treated by open/closed reduction and internal fixation using a retrograde femoral nail.

Methods: 30 patients with distal femoral fractures were studied. Cases were selected on the basis of purposive sampling technique. Demographic details such as age, sex, occupation, pre-fracture activity levels and type of fracture were recorded. All patients were treated by closed or open retrograde femoral nailing. Patients were followed up for 12-36 months and follow-up data such as time to union, range of knee movements and complications were noted.

Results: Assessment of final functional result was made using Lysholm knee scoring scale. 73% of our patients had excellent or good functional results. The average knee range of movement was 106^0(Range: 90-120^0) and the average time to union was 16 weeks (Range: 12-20 weeks).

Conclusion: Retrograde femoral nailing is an effective method for treatment of extra-articular and some selected intra-articular distal femoral fractures with advantages of reduced operative time, reduced blood loss and low incidence of complications like infection and knee stiffness. Early surgery, achieving closed reduction and early post-operative knee mobilization are essential for prompt union and good knee range of motion.

Key-words: *Distal femoral fractures, Retrograde Femoral Nailing, Lysholm knee score*

Introduction:

The incidence of femoral fractures and in particular, distal femoral fractures is on the rise due to rapid industrialization and urbanization leading to an increase in high-velocity injuries. Road traffic accidents account for a vast majority of these cases. Majority of these high velocity injuries are comminuted fractures and a significant number are open fractures. The incidence of distal femoral fractures is approximately 10 per 100000 and account for 5% of all femoral fractures.[1]

Fixation of distal femur fractures is usually complicated because of thin cortex, presence of comminution, osteopenia, complex associated soft tissue injuries, a wide distal medullary canal and frequent intra-articular involvement.[2] For the same reasons, distal femoral fractures are difficult to treat and have the potential to produce significant long term disability with poor results. Earlier efforts to treat these fractures non-operatively with skeletal traction resulted in complications like angular deformity, knee stiffness and post-traumatic osteo-arthritis.[3] Dissatisfaction with prolonged confinement to bed and poor knee function which were commonly encountered with traditional methods lead to development of newer techniques of fracture management. It is now recognized that distal femoral fractures are best treated with open/closed reduction and surgical stabilization.[4] Surgical treatment avoids the complications associated with non-operative treatment, such as prolonged immobilization, nonunion and mal-union.[5]

The options for surgical treatment are open reduction and internal fixation with Dynamic condylar screw, 95 degree angled blade plate, non-locking distal femoral condylar buttress plate, locking distal femoral condylar buttress plate, minimally invasive percutaneous plate osteosynthesis (MIPPO), less invasive stabilization system (LISS plate technique), antegrade femoral interlocking nailing and retrograde intramedullary interlocking nailing. Currently the most popular implants for fixing distal femoral fractures are angular-stable anatomical locking plates and locked intramedullary nails.[6]

Retrograde intramedullary nailing by virtue of its intra-medullary position has a biomechanical advantage over the laterally placed conventional devices. The intramedullary position of the nail decreases the lever arm and hence is believed to reduce the coronal plane angulation.[7] Aside from the theoretical biomechanical advantage of retrograde nailing over plating, both Lucas and co-workers[8] and Danziger and associates[9] reported that treatment of complex distal femoral fractures with this system was also associated with decreased blood loss, operative time, periosteal stripping and allowed the intramedullary reaming debris to be used as bone graft. Minimizing soft tissue dissection in already compromised tissue also help in reducing incidence of infection, early mobilization and good functional outcome. In addition, the use of a medial para-patellar approach for surgical exposure and nail insertion permits direct visualization of the articular surface, thus facilitating anatomic reduction.

The purpose of our study was to evaluate the results of distal femoral fractures treated by retrograde femoral nailing in relation to time for bony union, range of knee movements, complications and technical difficulties encountered in our set-up and to examine the currently advised post-operative rehabilitation protocol against the background of available literature.

Methodology:

This is a prospective study conducted between 2011 and 2014 in a tertiary care referral and teaching institution. In this study 30 distal femur fractures were treated by distal femoral nailing. Patients above 18 years with distal femoral fractures of AO type A1, A2, A3, C1 and C2 were included in the study. Patients with Gustilo-Anderson Type I and Type II open fractures were also included in the study. Patients who were below 18 years, pathological fractures of the distal femur, Gustilo-Anderson type III open fractures, AO type B and C3 fractures and fractures with associated vascular injuries were excluded from the study.

Following admission all patients were evaluated with full length antero-posterior and lateral radiographs of the affected limb. CT scans were performed wherever necessary when there was a doubt about the likelihood and extent of intra-articular involvement. AO classification was used to classify the fracture pattern.[10] Gustilo-Anderson classification was used to classify open fractures.[11,12] All patients with open fractures were taken up for debridement and primary nailing within 24-hours under the cover of appropriate antibiotics as per hospital protocol. Patients with closed fractures and patients with medical co-morbidities were taken up for surgery between 2-7 days after optimizing their general condition.

All patients were operated under spinal or epidural anesthesia. A sand-bag was placed under the buttocks to prevent external rotation of the hip

and to make orientation of the femoral condyles easier. Limb was draped free to assess the rotation intra-operatively. Most of the fractures were reduced by closed reduction while some required open reduction. Fracture was reduced by manual traction and knee flexion. Entry point was taken with the knee flexed to 30 degrees. It was seen that with less flexion the tibial plateau hindered the guide wire insertion and with more flexion the patella came in the way of taking the entry point. All the nails used were of stainless steel and nails were inserted after reaming the canal. Nail length and size chosen was such that a maximum sized nail could be accommodated into the femur. Distal locking was done first using with the help of the insertion guide on the insertion handle. Intra-operatively, diathermy cable was used to assess the right rotation and alignment. Proximal locking was done by the aiming device attached to the insertion handle. Fractures with intra-articular extension were reduced and fixed with one or two cancellous screws of size 6.5mm placed anteriorly so as to not interfere with the nail insertion. In these cases extreme care was used to ream and insert the nail gently so as not to lose the intra-articular reduction. At the end of surgery, a gentle examination of the knee joint was done to determine if there was any associated ligamentous laxity.

Post-operatively all patients except those having severe comminution and osteoporosis were mobilized on the second day with hip, knee and ankle range of motion. Patients were made to sit up in bed with both legs hanging free by the bedside with knee range of movements and quadriceps exercises. Patients were then trained to mobilize non-weight bearing with special emphasis on upper-limb strengthening especially in elderly patients. Sutures were removed two weeks after surgery.

Patients were followed up at 6 weeks, 12 weeks, 6 months, 9 months and 12 months both clinically and by radiographs. Clinical assessment included assessment of pain, the range of knee movements (as measured by a goniometer), mobilization status and documentation of full return to pre-fracture level of activity and deficiency in the same if any. Radiographic evaluation included monitoring of the progress of union, any progressive collapse of the fracture or deformities at the fracture site and to note for changes suggestive of implant failure, if any. We allowed partial weight bearing with support after noting the 6-week radiograph which showed bridging callus. Patients were taught to slowly progress to full-weight-bearing with support by 12 weeks. Over the next 2-4 weeks patients were encouraged to discard the support and walk independently. At one year functional evaluation of the knee was made by Lysholm scoring and results were classified as excellent, good, fair and poor outcomes.[13]

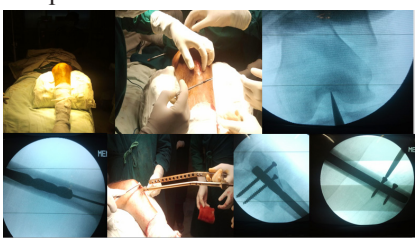

Fig 1: An overview of the surgical steps A: Patient position. B: Midline infra-patellar incision C: Entry point D: Canal reaming E: Nail insertion F: Distal locking G: Proximal locking

Results:

A total of 30 patients were treated by retrograde femoral nailing during the study period between 2011 and 2014. The mean age of patients was around 44 years (Range 18-81 years). There were 18 patients below the age of 50 years and 12 patients above the age of 50. 16 patients (53%) were males and 14 patients (47%) were females. In the group of patients below 50 years majority (14) were males and in the group with patients above 50 years, majority (10) were females. The mechanism of injury was due to road traffic accidents (high velocity injury) in 22 patients (73%) and domestic falls/falls from standing height (low velocity injury) in 8 patients (27%). Left femur was involved in 16 cases and right in 14 cases. There were 25 cases with extra-articular fractures and 5 cases with intra-articular fractures. AO Type A1 included 9 cases, Type A2 13 cases, Type A3 3 cases, Type C1 3 cases and Type C2 2 cases. There were 22 closed fractures and 8 open fractures of which 5 were Type 1 open and three were Type 2 open fractures. Nine patients (30%) had associated injuries which included two ipsilateral tibia fractures, two ipsilateral patella fractures, two ipsilateral distal radius fractures, one old operated ipsilateral fracture neck of femur with Austin Moore prosthesis in situ, one old operated intertrochanteric femur fracture with DHS in situ and one with head injury.

Majority of the fractures were reduced by closed reduction. However, in 5 cases with AO Type C fractures, open reduction was needed to obtain anatomical reduction and joint congruity. The mean operative time in our study was 86 minutes. The average operative time in the closed reduction group was 81 minutes and in the open reduction group (intra-articular fractures) was 108 minutes. All the fractures united with a mean time to union of 15.1 weeks in our study with a range of 12-24 weeks.

On an average, AO Type A fractures united faster than Type C fractures. At one year follow-up the mean range of motion of the knee was 106 degrees (Range 90-120). AO Type A fractures had better range of motion compared to Type C fractures and also younger patients had better range of motion when compared with older patients. The average follow-up time was 17 months (Range: 12-24 months). At one year follow-up the mean Lysholm score was 89.3 with a range between 63 and 99. As per the Lysholm criteria of grading the outcomes we had 10 (33%) excellent results, 12 (40%) good results, 7 (23%) fair results and 1 (3%) poor result. Overall the excellent and good results accounted for 73% cases.

In 3 cases we faced difficulty in proximal locking with the locking bolt passed through the aiming device missing the locking hole. This was attributed to the quality and accuracy of the instrumentation and the influence of the femoral bow. We had two cases with superficial infections which settled with culture specific antibiotics without needing any additional procedures. Both cases were Type II open fractures. Shortening of the affected limb between 2 and 5 cm was noted in 4 cases. Varus deformity of less than 10^0 was noted in 3 patients. Extensor lag was noted in 10 patients. 3 patients had anterior knee pain. None of the patients had delayed union or non-union. None of the patients had knee joint infection.

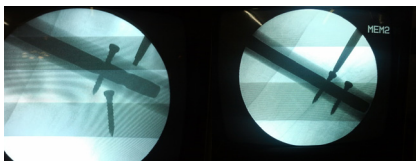

Fig 2: A: Difficulty in proximal locking using the proximal aiming device. B: The locking was later done by free-hand technique

Table 1: Summary of the demographics and study results

Age	Mean = 44 years (Range 18-81 years)
• Age < 50 yrs	18 (60%)
• Age > 50 yrs	12 (40%)
Sex	
• Males	16 (53%)
• Females	14 (47%)
Mechanism of Injury	
• High-velocity injury	22 (73%)
• Low-velocity injury	08 (27%)
Side involved	
• Left	16 (53%)
• Right	14 (47%)
Fracture pattern	
• Extra-articular	25 (83%)
• Intra-articular	05 (17%)
AO Type	
• A1	09 (30%)
• A2	13 (43%)
• A3	03 (10%)
• C1	03 (10%)
• C2	02 (7%)
Gustilo-Anderson Classification	
• Closed fracture	22 (73%)
• Open fracture	08 (27%)
Type 1 open	05
Type 2 open	03
Mean Operative Time	86 min (Range 60-130 min)
• Closed Reduction	81 min
• Open reduction	108 min
Mean Follow-up	17 months (Range 12-24 months)
Mean time to union	15.1 weeks (Range 12-24 weeks)
Mean Knee Range of Motion	106 degrees (Range 90-120 degrees)
Mean Lysholm Score at one year	89.3 (Range 63-99)
Lysholm Grading of results	
• Excellent	10 (33%)
• Good	12 (40%)
• Fair	07(23%)
• Poor	01(3%)
Complications	
• Sup. infections	2
• Shortening	4
• Varus	3
• Extensor lag	10
• Anterior knee pain	3

Discussion:

Supracondylar and intercondylar fractures of the distal femur are complex fractures that are difficult to treat. Successful treatment of peri-articular and intra-articular fractures especially in weight bearing joints requires restoration and maintenance of the congruence of the articular surfaces and alignment of the fracture to reestablish the normal mechanical axis of the lower limb.

There is a bimodal distribution of the incidence of these fractures with age.[14] The first group includes youngsters, especially young men, after high-energy trauma. These fractures are often open, comminuted, and most probably the result of direct application of load to a flexed knee caused by motorcycle accidents or fall from a height. Among our patients, majority of the younger patients were males and had a high-velocity injury. In the older group, most of the injuries occur in elderly women after moderate trauma, such as a fall from a standing height on a flexed knee.[15] In our study all except one patient in the group with low velocity injuries were females above 50 years suggesting osteoporosis as a possible cause for these fractures. It was also note-worthy that all fractures caused by low-velocity injuries were either AO Type A1 (metaphyseal-simple) or A2 (metaphyseal-wedge) fractures.

Fractures in the supracondylar area characteristically deform with femoral shortening and posterior angulation and displacement of the distal fragment. Shortening is due to the pull of the quadriceps and hamstring muscles, while the varus and extension deformity is caused by the unopposed pull of the adductors and gastrocnemius, respectively. In twenty five of the thirty fractures treated in our study, the fracture was reduced closed by manual traction and knee flexion to relax the gastrocnemius. In more severe fractures with intercondylar involvement, one often sees rotational malalignment of the condyles relative to each other in the frontal plane, a result of their muscle attachments. In five such cases open reduction was needed to achieve articular reduction in our study.

Though the use of retrograde intra-medullary nailing from an intra-articular, intercondylar approach was introduced during the late 1980s it was only in 1993 Lucas and co-workers reported the earliest follow-up of 25 AO type A and type C distal femoral fractures treated with the retrograde femoral nailing. All fractures in their series united but 4 of the 19 type C fractures eventually required bone grafting for achieving union.[8] Danziger and associates in 1995 reported that they had achieved union and good to excellent results in 15 of the 16 patients in their series with supracondylar - intercondylar distal femoral fractures treated with retrograde femoral nailing.[9]

Retrograde femoral nailing offers indirect reduction with less soft tissue exposure and theoretically less interference with fracture healing than occurs with plate fixation through the conventional lateral approach. Nails offer two theoretical advantages; the mechanical impact of a long intramedullary device that is close to the axis of the femur[16] and the biological advantages of minimal disruption of the fracture site and stimulation of blood supply by reaming.[17] Proximal and distal locking screws help maintain reduction. However, direct exposure and adequate reduction with supplementary internal fixation are still required for intra-articular fractures. It is also valuable to note that nail insertion does not restore alignment of metaphyseal fractures as it does in the diaphysis. Theoretical concerns about knee joint damage due to nail insertion through the articular surface have not been answered with long-term follow-up studies, although problems have not been obvious.[18,19]

For properly selected AO Type A and C (C1 & C2) fractures with careful planning and well-executed procedures retrograde femoral nailing provides a valuable addition to the surgeon's armamentarium. Retrograde nailing is an advantageous and attractive option for patients with ipsilateral hip fractures or previous hip fractures with implant in situ. In our study we has one patient with a previously treated fracture neck femur with Austin Moore Prosthesis and another patient with previously treated IT fracture with DHS in situ who presented with distal femur fractures. Retrograde femur nailing is also a good option in patients presenting with floating knee injuries.[20,21] We had two patients who presented with ipsilateral tibia fractures in our study who were treated by retrograde femur nailing and antegrade tibia nailing through the same incision.

In the thirty patients studied in our series all fractures united with a mean time of 15.1 weeks (Range 12-24 weeks) and with an average knee flexion of 106 degrees (Range 90-120 degrees). Literature from the west recommends touch-down weight bearing (10-15kg) immediately after surgery with the help of crutches or walker. We preferred to keep our patients non-weight bearing because many of our patients could not comprehend the concept of touch-down weight bearing. Rather, we focused on attaining knee range of

motion, quadriceps strengthening and upper-limb strengthening and kept them non-weight bearing until we assessed the 6 week radiographs. At one year follow-up the mean Lysholm score in our patients was 89.3 with a range between 63 and 99. As per the Lysholm criteria of grading the outcomes we had 10 (33%) excellent results, 12 (40%) good results, 7 (23%) fair results and 1 (3%) poor result. Overall the excellent and good results accounted for 73% cases. Our results compare well with other standard studies of retrograde femoral nailing for distal femoral fractures by Lucas et al.[8] Gellman et al.[22] and Patel et al.[23] None of the patients in our study underwent implant removal though they were counseled about implant removal.

Our study was not without limitations. The short follow-up of 12-24 months with an average of 17 months and the small number of cases were the main drawbacks. Though there are questions raised about the long-term damage to the knee joint by breech of the articular cartilage by the procedure our study has not ventured into examining such effects on knee joint function. Perhaps a study with a longer term follow-up can throw more light on the concerns of long-term damage to the knee joint.

Conclusion:

Retrograde femoral nailing is an effective method for treatment of extra-articular and some carefully selected intra-articular distal femoral fractures with the advantages of biological fixation, reduced operative time, reduced blood loss and lower incidence of complications like infection and knee stiffness. Retrograde nailing with a rigid intramedullary device combines the biomechanical advantage of intramedullary fixation with the stability of rigid internal fixation in these fractures. Intramedullary fixation provides improved fracture stabilization in both elderly patients with osteoporotic metaphyseal bone and in younger patients with extensively comminuted fractures. The results can be improved further by achieving normal limb length, alignment and normal rotation by closed reduction wherever possible with early and aggressive knee mobilization under close clinical and physical therapy monitoring

Conflict Of Interest: None

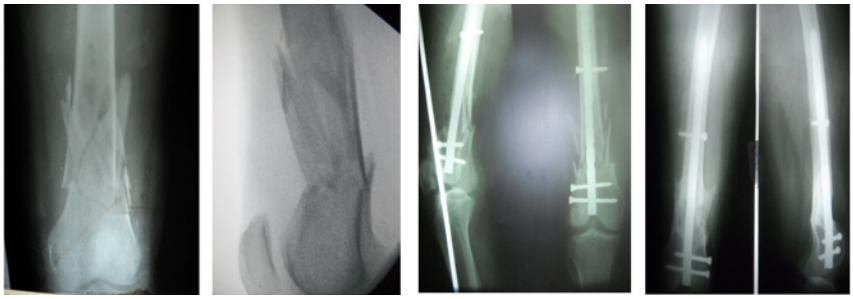

Figure. 3: A,B: AO Type A3 fracture, C: Immediate post-op, D: Union at 16 weeks

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