Original Research Article

Outcome analysis of retrograde nailing for surgical stabilization of distal 1/3rd fracture shaft femur: A hospital based study

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Abstract

Background: The distal 1/3rd femoral fractures constitute 6% of all femoral fractures. These fractures pose a great challenge in management due to the involvement of soft tissue injury, intra-articular extension, and injury to the extensor mechanism. The debates on the choice of implant for distal femoral fractures are on-going among orthopedic surgeons. Retrograde approach through the femoral intercondylar notch has been popularized in the recent years as an alternative to antegrade nailing. Surgical treatment of periarticular and intra-articular fractures of the distal femur pose a significant challenge to the orthopedic surgeon. The primary goal of surgical treatment remains: restoration of the articular surface to the femoral shaft, while maintaining enough stability and alignment to enable early range of motion and rehabilitation. The aim of this study was to investigate its effectiveness in fixation of distal 1/3rd fracture of femur with special emphasis on the outcome and inherent surgical challenges. **Material & Methods**: A prospective study of 20 patients with fracture femur diaphysial distal one third were treated by retrograde nailing, from January 2019 to December 2020, after obtaining required approval from the Institutional ethics committee. All the patients were followed till fracture union and evaluated on the basis of demography, duration of healing, complications and surgical challenges. **Results**: In the present study, out of 20 study subjects there were 7 patients (35%) in the age group of 31-40 yrs followed by 6 patients (30%) were in the age group of 31-40 yrs, 4 patients (20%) were in the age group of 41-50 yrs, 2 patients (10%) in the age group of 51-60 yrs with mean age of the patients was 43.6 ± 17.67 years. There were 17 patients (85%) male and 3 patients (15%) female. The mode of injury in case of majority of the patients had RTA [road traffic accidents] 11 patients (55%), followed by fall from height 5 patients (25%), sports injury 2 patients (10%) and domestic injuries 2 patients (10%). Mean time from the injury to operation was 3 days. The mean duration of the surgery was 100 mins. Majority of the patients 16 (80%) had isolated femoral fractures while others 4 patients (20%) had polytrauma. Mean time of the fracture healing was 18.5 weeks [SD ± 6.75]. In the present study we have observed that the post-operative knee range of motion (ROM) achieved; 8 patients (40%) had 125º, 4 patients (20%) had 135º, 2 patients (10%) had 140º, 2 patients (10%) had 105º, 3 patients (10%) had 110º, 1 patient (5%) had 115º, and with mean of 123.75º post-operatively. **Conclusion:** Retrograde nailing for surgical stabilization of distal 1/3rd fracture shaft femur is adequate treatment options for distal femur fractures. Locked plating can be used for all distal femur fractures including complex type C fractures, periprosthetic fractures, as well as osteoporotic fractures. IM nailing provides favorable stability and can be successfully implanted in bilateral or multisegmental fractures of the lower extremity as well as in extra-articular fractures. Clinical outcome largely depends on surgical technique rather than on the choice of implant.

Keywords: Distal femur fracture, Retrograde nailing (RN), Outcome

Introduction

Distal femur fractures include fractures of the supracondylar and intercondylar region of the distal femur and are relatively common injuries. To avoid the high morbidity and mortality correlating with this fracture, it requires prompt diagnosis and treatment [1]. The distal 1/3rd femoral fractures constitute 6% of all femoral fractures [2]. These fractures occur in bi-modal distribution as high energy trauma in younger age group and low energy fractures due to osteoporosis in the elder age group.

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Due to extensive comminution, soft tissue damage, an extension of the fracture into the knee joint, neurovascular damage and injury to the extensor mechanism in the distal femur, these distal femur injuries were complicated and difficult to manage [3].

The goals of treatment follow AO principles of anatomic reduction of the articular surface, restoration of limb alignment, length, and rotation. Despite improvements in implant design, management of distal femur fractures remains a challenge; fractures are often comminuted, intra-articular, and involve osteoporotic bone, making fixation challenging to achieve. In the geriatric trauma population, the incidence of co-morbidities is high and may impact the therapeutic options [1].

Distal femur fractures account for less than 1% of all fractures and about 3 to 6% of all femoral fractures [4, 5]. These fractures occur in a bimodal distribution: young males, particularly after high-energy motor trauma and elderly females. One study reported that 80% of patients 35 years of age or older with a distal femur fracture secondary to moderate trauma had evidence of generalized osteopenia [6]. Supracondylar femoral fractures occur commonly among two populations, young patients involved in high-energy accidents (including motor vehicle and motorcycle accidents and sports trauma)

and older patients, often osteoporotic, sustaining low-energy fall fractures. Jahangir additionally described an increase of periprosthetic fractures of the distal femur in patients with previous total knee arthroplasty or distal to a total hip arthroplasty as the third common population [7]. Definitive treatment of distal femoral fractures requires maintenance or restoration of distal femoral alignment to preserve the function of the extremity [8]. Additionally, early knee motion is central to the management of distal femoral fracture. Knee stiffness and loss of range of motion (ROM) may develop with immobilization [9], and these often contribute to a poor outcome [10]. The diversity of surgical options for the management of distal femoral fractures reflects the challenges inherent in these injuries. These fractures are frequently comminuted and intra-articular, and they often involve osteoporotic bone, which makes it difficult to reduce and hold them while maintaining joint function and overall limb alignment. Surgery has become the standard of care for displaced fractures and for patients who must obtain rapid return of knee function. The goal of surgical management is to promote early knee motion while restoring the articular surface, maintaining limb length and alignment, and preserving the soft-tissue envelope with a durable fixation that allows functional recovery during bone healing. A variety of surgical exposures, techniques, and implants has been developed to meet these objectives, including intramedullary nailing, screw fixation, and periarticular locked plating, possibly augmented with bone fillers [11].

Retrograde nailing is a viable option for the treatment of distal femur fractures. The advantages of retrograde nailing include: the intramedullary nail is a load-sharing device compared to plate fixation, the nail may be inserted through smaller incisions causing less soft tissue disruption, and it allows for the treatment of ipsilateral hip and ipsilateral tibia fractures in the polytrauma patient. Retrograde nails of standard-length should extend to the level of the lesser trochanter to prevent a stress riser in the subtrochanteric region. Newer implants with options for multiple distal screw fixation allow for the restoration of the articular surface for simple intra-articular fractures. Biomechanical studies demonstrate that the number, orientation of the distal locking screws, and quality of distal screw purchase are essential components in determining the strength of a nail [12].

A recent study concluded that intramedullary nails might have superior outcomes compared to anatomic locking plate devices for fractures of the distal femur [13]. Potential disadvantages to retrograde nailing include knee sepsis, patellofemoral pain, and synovial metallosis from the nail or screw breakage. OTA 33 type C3 fractures with severe comminution may not be optimal for stabilization with a nail [1]. Technically the proximal locking in retrograde nailing can be challenging as the lateral target device often mismatch in proximal locking due to strong muscle forces. To negotiate this problem recent nail designs are considering anterio-posterior free hand locking option for proximal locking. The primary goal of surgical treatment remains: restoration of the articular surface to the femoral shaft, while maintaining enough stability and alignment to enable early range of motion and rehabilitation. The aim of this study was to investigate its effectiveness in fixation of distal 1/3rd fracture of femur with special emphasis on the outcome and inherent surgical challenges.

Material & methods

A prospective study was done in a tertiary care teaching hospital, Durgapur, West Bengal 20 patients of distal 1/3rd fractures of femur treated by retrograde nailing from January 2019 to December 2020, after approval from institutional ethics committee. The femoral shaft was divided into 3 equal segments and only fractures with the major fracture line in the distal third were included. Fractures without involvement of the lower third of the femoral shaft, those with a supracondylar/intercondylar extension, grade-III open fractures, and those with an open physeal plate were excluded. All relevant data were collected in a structured proforma. All the patients were followed till fracture healing (average 6 months) and were evaluated on the basis of demography, duration, percentage of healing, complications, range of motion, and surgical challenges. Written informed consent was taken from individual study participants.

Operative procedure

The patient is positioned supine on a radiolucent table. Knee is kept in slight flexion (20 to 50 degree) by keeping a bump below the knee. The optimal starting point for the procedure is in the intercondylar notch 1 finger breadth anterior to the PCL origin, similar to the location where a femoral intramedullary guide rod would be placed during TKR.

There are at least 4 ways to approach inter-condylar notch. Medial parapatellar arthrotomy- this approach is preferable when there is intra-articular fractures which require reduction and fixation. Per cutaneous technique (patellar tendon retraction) - an incision about 5-7 cm is made from inferior border of patella to superior border of tibial tuberosity. The patellar tendon is retracted laterally and entry point is localized. Percutaneous technique (splitting the patellar tendon) - an incision is made from inferior border of patella to the superior border of tibial tuberosity. The patellar tendon is split in the middle and entry point is located. Arthroscopic localization- after localizing entry point 1 finger breadth anterior to the PCL origin, a bone awl is kept over it the position of the awl is confirmed in the IITV. The awl is advanced into the condylar notch. After which a thin solid 7 mm entry reamer is introduced in the canal .once the position in the medullary canal is satisfactory we introduce a guide wire in the medullary canal . Fracture reduction is achieved by traction, closed manipulation, adjustment of the bolster underneath the knee and guide wire negotiated through fracture site. Once the guide wire is in canal reaming is done, gradually upto the required diameter. The surgeon should be careful to avoid any contact between reamer and the patella by using tissue protractor and reamer sleeve.

In our study we reamed one size higher (i.e. 11 mm for a 10 mm nail). We keep 9 mm to 12 mm diameter options in stock. We reamed canal only up to desired length of nail say 30 cm reaming for 30 cm nail. This helped us to negotiate nail with limited reaming of the canal to avoid complications of reaming. Once reaming was done, the nail of required length and diameter was introduced. We used nails of a maximum 30 cm length and a minimum 15 cm length. Hence only those patients who had fracture within 25 cm of distal-end of femur were included in this study. Once the nail is introduced, locking was performed using lateral targeting device. The nail had 3 locking options in distal region and two in the proximal. Distal locking bolts were 6.5 mm caliber and proximal locking bolt were 5mm.

Postoperative Management

Postoperative knee brace was given with gradual knee bending with quadriceps and hamstring. Weight bearing was begun as early as possible, depending upon the fracture anatomy, quality of fixation and concomitant injuries. Presence of callus on radiograph helped to decide the ambulation program. Occasionally continuous passive motion programme was initiated to gain the desired range of movement.

Outcome measures included (1) time taken for union—fracture was considered united when the patient could walk painlessly without aid and when bridging callus was shown on at least 3 cortices on radiography, (2) time to initiation of weight bearing, (3) angular deformity (as measured on the antero-posterior and lateral radiographs after union), rotational deformity, and limb length discrepancy (as assessed by clinical examination), (4) functional length of the nail in each fracture segment, (5) nail-canal diameter mismatch, (6) the status of the knee, according to Knee Society Knee Score. Malunion was defined as more than 5° of angular deformity or more than 1 cm of limb length discrepancy or more than 10° rotational deformity [14].

Results

In the present study, out of 20 study subjects there were 7 patients (35%) in the age group of 31-40 yrs followed by 6 patients (30%) were in the age group of 31-40 yrs, 4 patients (20%) were in the age

group of 41-50 yrs, 2 patients (10%) in the age group of 51-60 yrs with mean age of the patients was 43.6 ± 17.67 years. There were 17 patients (85%) male and 3 patients (15%) female [Table 1]. The mode of injury in case of majority of the patients had RTA [road traffic accidents] 11 patients (55%), followed by fall from height 5 patients (25%), sports injury 2 patients (10%) and domestic injuries 2 patients (10%) [Table 2].

Table 1: Demographic particulars of fracture shaft femur patients [n=20]

Characteristics	N (%) or mean ± SD
Male	17 (85%)
Female	03 (15%)
Age (years)	43.6 ± 17.67
Age groups	
21-30 yrs	6 (30 %)
31-40 yrs	7 (35 %)
41-50 yrs	4 (20 %)
51-60 yrs	2 (10 %)
Above 60 yrs	1 (5%)

Table 2: Mode of injury among fracture shaft femur patients [n=20]

Mode of Injury	
RTA	11 (55%)
Sports injury	2 (10%)
Fall from the height	5 (25%)
Others	2 (10%)

Table 3: Types of Fractures among fracture shaft femur patients [n=20]

Types of Fracture	
Closed fracture	14 (70%)
Compound fracture	6 (30%)
Isolated femoral fractures	16 (80%)
Polytrauma	4 (20%)

Out of all study participants 14 patients (70%) had closed fractures and rest 6 patients (30%) had compound fractures. Isolated femoral fractures were noted in 16 (80%) and rest were 4 (20%) polytrauma [Table 3].

Table 4: Clinical characteristics and outcomes among fracture shaft femur patients [n=20]

Mean time from the injury	3 days
Mean duration of the surgery	100 mins
Mean time of the fracture healing [±SD]	18.5 weeks [±6.75]
Post-operative knee range of motion (ROM) achieved	8 patients (40%) had 125º, 4 patients (20%) had 135º, 2 patients (10%) had 140º, 2 patients (10%) had 105º, 3 patients (10%) had 110º, 1 patient (5%) had 115º, mean of 123.75º post-operatively

Mean time from the injury to operation was 3 days. The mean duration of the surgery was 100 mins. Majority of the patients 16 (80%) had isolated femoral fractures while others 4 patients (20%) had polytrauma [Table 3, 4]. Mean time of the fracture healing was 18.5 weeks [SD ± 6.75]. In the present study we have observed that the post-operative knee range of motion (ROM) achieved; 8 patients (40%) had 125º, 4 patients (20%) had 135º, 2 patients (10%) had 140º, 2 patients (10%) had 105º, 3 patients (10%) had 110º, 1 patient (5%) had 115º, and with mean of 123.75º post-operatively [Table 4].

Complications

We had noticed complications in 3 patients (15%) out of which 2 patients (10%) had knee joint pain (causes being- nail impingement & iliotibial band irritation by the locking screw), out of these 3, 1 patient (5%) was re-operated, out of these two one was re-operated due to painful knee impingement of the nail (protrusion of the nail) with the exchange nailing with careful deep seating of the new nail. About 15% (3/20) cases developed painful knee and decreased range of motion due to protrusion of nail in intercondylar notch 2 of which had minimal 1or 2 mm protrusion which became asymptomatic with time. One patient developed post operating infection with painful septic arthritis for which through joint lavage and suction irrigation was done and antibiotic according to sensitivity was given which eventually healed but resulted in a stiff knee. Failure to achieve proximal locking that occurred in 2 cases, when there was a mismatch between targeting device and the proximal hole. In all the 2 cases error was discovered on the operation table. Most causes were related to muscle forces, patients positioning and implant design. Degree of knee flexion was adjusted to negotiate the muscle forces and locking could be achieved.

Discussion

Hierholzer C et al study revealed that clinical and radiographic evaluation demonstrated osseous healing within 6 months following RN and following LISS plating in over 90% of patients. However, no statistically significant differences were found for the parameters time to osseous healing, rate of nonunion, and postoperative complications. The following complications were treated: hematoma formation (one patient RN and three patients LISS), superficial infection (one patient RN and three patients LISS), deep infection (2 patients LISS) [15].

Gao K et study revealed that no differences were found with respect to postoperative mal-reduction, deep infection, hardware failure, operating time, knee pain, HSS score and range of knee movement. The mean intraoperative blood loss was significantly higher in the RN (retrograde nailing) group (298 ± 65.2 ml, range 200–410) than in the LP group (200 ± 48.9 ml, range 130–300) ($p < 0.01$). However, a

higher rate of union disturbance was observed in the LP (locked plating) group (36.8%) compared to the RN group (5.9%) (p = 0.044). The overall union disturbance rate in the LP group was higher than in the RN group. However, further analysis revealed that clinical outcome may largely depend on surgical technique rather than on the choice of implant. Therefore, correct rules (the same for every procedure) should be strictly adhered to, especially in the application of LP [16].

In Prasanna A et al study, 113 cases underwent surgical management with distal femoral retrograde nailing. The results were analyzed according to Lysholm's knee scoring showed excellent in 55 cases (48.67%), good in 39 cases (34.51%), fair in 11 cases (9.73%) and poor in 8 cases (7.07%). The correlation analysis with Pearson's correlation coefficient (r) was 0.8 which show a highly positive correlation between the union of distal femoral fracture and retrograde distal femoral nailing [17].

There has always been a concern for potential patella-femoral arthritis with an intra-articular entry portal. To date, there has not been enough long-term follow- up to determine whether this should truly be a concern. Some authors have argued that retrograde nailing probably does not lead to significant posttraumatic arthritis because the intercondylar entry point is not in a weight-bearing area and is brought into contact with the patella only in extreme flexion.

In Acharya KN et al study 26 (93%) patients of the 28 fractures achieved union, of which 5 underwent dynamisation; the mean union time for the other 21 fractures was 4.4 months. Angular malalignment was present in 4 patients and shortening in 4 others. There was negligible correlation between union time and variables of nail-canal diameter mismatch, functional length of nail, fracture geometry, or initiation of partial weight bearing ambulation. Knee flexion of more than 100 degrees was achieved in 26 patients. 19 patients had anterior knee pain and 10 had instability. By the end of one year, excellent or good scores for pain and function were recorded in 77% and 73% respectively, of the 26 patients. In view of such favourable union rates but significant deterioration in overall knee joint function, at best retrograde nailing is a reliable alternative in the management of selected complicated fractures of the distal femoral shaft [18].

Surgical treatment of periarticular and intra-articular fractures of the distal femur pose a significant challenge to the orthopedic surgeon. The primary goal of surgical treatment remains: restoration of the articular surface to the femoral shaft, while maintaining enough stability and alignment to enable early range of motion and rehabilitation [19].

Treatment options for the treatment of distal femur fractures include open reduction and internal fixation with periarticular locking plates, intramedullary nails, or distal femur replacement. Despite rapid adoption, these modern solutions display a concerning complication rate, specifically from nonunion and malunion [20]. Fracture comminution and intra-articular extension can make it difficult to obtain an adequate reduction while preserving the soft tissue attachments to bone fragments to allow for bone healing. Many implant manufacturers have developed optimal anatomically contoured, distal femoral locking plates with percutaneous guides. In view of such favourable union rates but significant deterioration in overall knee joint function, at best retrograde nailing is a reliable alternative in the management of selected complicated fractures of the distal femoral shaft [21].

Fractures of the distal femur are rare and severe. The estimated frequency is 0.4% with an epidemiology that varies: there is a classic bimodal distribution, with a frequency peak for men in their 30s and a peak for elderly women; however, at present it is found predominantly in women and in the elderly with more than 50% of patients who are over 65. The most common mechanism is an indirect trauma on a bent knee, and more rarely direct trauma by crushing. The anatomy of the distal femur explains the three major types of fracture. Because of the anatomy of the distal femur, only surgical treatment is indicated to stabilize the fracture. A non-surgical treatment is a rare option [22].

Hierholzer C et al (2011) study revealed that clinical and radiographic evaluation demonstrated osseous healing within 6 months following retrograde intramedullary (IM) nailing (RN) and less invasive stabilization on system (LISS) plating in over 90% (n=104) of patients. Time to healing was not significantly different between the groups. In the RN group 5 out of 59 patients (9%) developed nonunion as no bony consolidation of the femoral fracture was observed 6 months after osteosynthesis. In the LISS group, nonunion was observed in 6 out of 56 patients (12%). There was no statistically significant difference between the two groups for the development of nonunion. However, no statistically significant differences between the nail and the LISS group were found for the parameters time to osseous healing, rate of nonunion, and postoperative complications. Radiographic signs of healing correlated with clinical signs of healing, including the absence of pain or tenderness over the fracture site and the absence of pain with motion. The additional secondary bone grafting or bone substitute (BMP) was required, 3 months after the primary operation in four patients (7%) in RN group and six (12%) in LISS group [15].

Nagla A et al observed that mean age of patients was 35.8 years (18 years to 62 years) where 87.5% were male and 12.5% were female. Average duration of healing was 17.75 weeks (ranging from 10 weeks to 36 weeks) with 100% healing achieved. Mean knee range of motion was 124.5 degree (70 to 140 degree), rate of knee pain 10% (4/40), re-operation rate 5% (2/40), infection rate 2.5% (1/40), and fat embolism 2.5% (1/40). Retrograde femoral nailing is a reliable alternative to antegrade nailing or plate fixation for diaphyseal fracture distal one third femur, and may be in some situations even advantageous when antegrade nail entry is challenging like ipsilateral hip fractures, previous implant in hip & proximal femur, ipsilateral pelvi-acetabular injury, bilateral femoral shaft fracture, floating Knee injuries, poly-trauma and obese patients [23].

Both retrograde IM nailing and angular stable plating are adequate treatment options for distal femur fractures. Locked plating can be used for all distal femur fractures including complex type C fractures, periprosthetic fractures, as well as osteoporotic fractures. IM nailing provides favorable stability and can be successfully implanted in bilateral or multisegmental fractures of the lower extremity as well as in extra-articular fractures. However, both systems require precise preoperative planning and advanced surgical experience to reduce the risk of revision surgery. Clinical outcome largely depends on surgical technique rather than on the choice of implant [15].

Postoperative function of the knee has always been evaluated in terms of knee pain and/or range of movement, rather than as a comprehensive function. Though the Knee Society Knee Score18 was developed in relation to total knee replacement surgery, the first 2 components of the scoring system (knee score and knee function score) provided a suitable instrument for overall assessment in our study; the categorical score was omitted as it was not relevant. RN appeared to have a detrimental effect on the knee, as seen by the reduced knee score even one year postoperatively [18].

Retrograde nailing helps restore both form and function and produces remarkably good short and long-term results with low complication rates [24]. Initial results of retrograde technique using smaller-diameter nails showed promising results but higher non-union rates than that of antegrade nailing [25, 26]. When equivalent diameter (ie, 10 mm) nails were used, the reported non-union rate is the same as that of antegrade nails (< 5%).13,14,33 Initial results have also indicated an increased rate of knee problems including knee stiffness, patella baja, heterotopic ossification, and metallosis and medullary debris in the knee joint [27].

Conclusion

In view of such favourable union rates but good amount of deterioration in overall knee joint function, at best retrograde nailing is a reliable alternative in the management of selected complicated fractures of the distal femoral shaft. Distal third femoral shaft fractures are characterized by increasing incidence and complexity and are still considered a challenging problem (high morbidity and

mortality). The choice among the studied techniques must be based on surgeons' experience, indications and subjective patients' aspects.

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