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EARLY RESULTS OF NAIL PLATE CONSTRUCT IN ASEPTIC NONUNION OF JUNCTIONAL AREA FRACTURES OF DISTAL FEMUR.

Orthopaedics

Dr. Mondeep Gayan	Associate Professor, Dept. Orthopaedics, Diphu Medical College & Hospital, Diphu, Karbi Anglong
Dr. Partha S Chakrabarty	Professor & HOD, Dept. Orthopaedics, Diphu Medical College & Hospital, Diphu, Karbi Anglong
Dr. Abhijit Das *	Senior Resident, Dept. Orthopaedics, Diphu Medical College & Hospital, Diphu, Karbi Anglong *Corresponding Author
Dr. Devan P Nambiar	Senior Resident, Dept. Orthopaedics, Diphu Medical College & Hospital, Diphu, Karbi Anglong
Dr. Lenin Ligu	Associate Professor, Dept. Orthopaedics, Tomo Ribha Institute of Health & Medical Sciences, Naharlagun
Dr. Harikrishnan N.G.	Senior Resident, Dept. Orthopaedics, Jorhat Medical College & Hospital, Jorhat
Dr. Himashis Medhi	Assistant Professor, Dept. Physical Medicine & Rehabilitation, Diphu Medical College & Hospital, Diphu, Karbi Anglong
Dr. Indrajit Chakraborty	Postgraduate Trainee, Dept Orthopaedics, Guwahati Medical College & Hospital, Guwahati

ABSTRACT

Introduction: Junctional distal femur fractures are the fractures of the region, around the diaphyseal-metaphyseal junction of the femur from the knee joint line. The stability, displacement, and angulation are determined by the pattern of fracture and the biomechanics. Because of various deforming muscle pulls and instability, the junctional area distal femur fracture is highly prone to malunion, delayed union, and nonunion. Internal fixation is mandatory to provide the earliest weight bearing of patients. **Materials and Methods:** 12 patients more than 18 years old with aseptic nonunion of junctional area distal femur fractures between 1st April 2020 and 30th September 2022 were included in the prospective study. 4 cases had nonunion due to implant failure. All cases were managed with the Nail-Plate construct along with autologous bone grafting. **Results:** The mean duration of surgery was 105.2 minutes. All fractures united with a mean time of 14.6 weeks. At 6 months follow-up, good-excellent Neer's knee outcome was seen in 91.7% of the cases. There was 1 case of deep infection which had delayed union. **Conclusion:** The dual implant provides axial and bending stability along with compression and anti-rotational stability. This promotes union, provides good knee function, and allows confident earliest weight bearing in the immediate post-operative period. Hence, the nail-plate construct is effective in the treatment of aseptic nonunion of junctional area distal femur fractures.

KEYWORDS

Junctional area distal femur, aseptic nonunion, nail-plate construct, Neer, axial bending stability, rotational stability.

INTRODUCTION:

Junctional distal femur fractures are the fractures of the region, around the diaphyseal-metaphyseal junction of the femur from the knee joint line (terminal 10–15 cm of the distal femur), with their incidence being 3%–6% of all femoral fractures.[1] These fractures have a bimodal age distribution; occur mainly due to high-energy injuries (road traffic accidents in younger patients), and low-energy injuries (domestic self-falls in older osteoporotic patients). High-energy mechanism injuries are associated with the risk of nonunion because of disruption of the soft tissue envelope, so great care should be taken during the treatment of these conditions. In osteoporotic cases, complex and comminuted fractures are usually associated with poor outcomes.[2,3] The stability, displacement, and angulation are determined by the pattern of fracture and the biomechanics. Gastrocnemius muscle pull leads to the rotation and spread of the intercondylar fracture, whereas the adductors cause coronal plane deformities. Severe deformities are seen more frequently in elderly patients with a high degree of osteopenia. Because of these various deforming muscle pulls, the junctional area distal femoral fracture is highly prone to malunion, delayed union, and nonunion.[4]

Different modalities of management of non-union of junctional area distal femur fractures are nonsurgical (electrical ultrasound stimulation, extracorporeal shock waves, platelet-rich plasma therapy, etc.) and surgical.[5] Among surgical methods, 95[0] blade plate, dynamic condylar screw and plate, condylar buttress plates, distal femoral locking plate, and intramedullary nail (antegrade and retrograde) are the methods of internal fixation, and the Ilizarov fixator is the method of external fixation.[6,7]For the nonunion of such fractures (at the junctional area of the distal femur), treatment by exchange nailing (removal of intramedullary device, and replacement by a larger diameter nail via 1-3mm over-reaming of the medullary cavity) is recommended.[8] Even hypertrophic nonunion is quite commonly seen in failed internal fixation of nonunion of junctional area distal femur fractures treated with exchange nailing.[9,10]

This is mainly because of residual rotational instability after intramedullary device fixation, as the nail has poor hold inside the spacious medullary cavity of the distal femur in spite of the two locking bolts.[11]

Based on controversial results seen in several studies, this study aims to evaluate the functional and radiological outcome of augmented nail-plate construct in the treatment of patients with aseptic nonunion of junctional area distal femur fractures.

MATERIALS AND METHODS:

In this study, we treated 12 cases of aseptic nonunion of junctional area distal femur fractures between 1st April 2020 and 30th September 2022. Patients over the age of 18 years with aseptic femoral nonunion at the junction of the proximal 2/3rd and distal 1/3rd area, who gave informed consent were included in the study.

The study was approved by the Institutional Ethics Committee. Patients with infected nonunion, limb length discrepancy of more than 1.5 cm, history of use of corticosteroids and immunosuppressive drugs, pathological fractures, open fractures, and cases contraindicated for surgery were excluded from the study. The study

aimed to evaluate the functional and radiological outcome of the nail-plate construct in the treatment of aseptic nonunion in the junctional area distal femur fractures.

Surgical technique[12]:

In our study, all patients with distal femur junctional fractures were managed with antegrade intramedullary femur nails with augmented plating. A traction table was used to position the patient. Under IITV guidance, the entry point was made at the pyriform fossa, followed by insertion of the guidewire, and the guidewire passed distally to the fracture site after open reduction (after adequate freshening of fracture margins). Power reamers were used for reaming, with a subsequent increase in the size of the reamer (care was taken to always place our guidewire in the center of distal femur in AP and lateral views of fluoroscopy). The longest size nail with the largest possible diameter was inserted to increase working length and enhance the stability of the nail by inserting it as much distally as possible into the condyle. Because distal cortical contact improves stability, the large diameter of nail is necessary. We used the perfect circle technique for distal 2 lock bolts. Locking was done after impaction at the fracture site. For plate application, a mid-lateral incision was made over the lateral aspect of the distal femur. The iliotibial band was incised in line with the skin incision, and the vastus lateralis muscle was lifted anteriorly to expose the lateral aspect of the femur. The muscle was separated from the bone to insert the plate using minimally invasive techniques**.** We used K-wires to balance the plate temporarily, followed by the placement of locking screws distally. (Broad LCP / Narrow LCP was used in most of the cases as it provided the advantage of having an alternating screw hole, thus enabling screw insertion in front or behind the nail). Initially, 3.0mm K-wires were used for drilling using the miss-the-nail technique, followed by placement of 3 proximal screws via a mini-open or minimally invasive method. Similarly, 3 screws were put in the distal fragment. To interlock the nail plate construct as a single construct, an effort was made to thread one screw through the plate hole into the nail's distal locking holes, thus reinforcing the construct with the fixed angle locking mechanism with the help of perfect circle technique. Plating was done based on the wave plate design because it allows easy placement of autografts around nonunion site, increases functional diameter around the nonunion site, and provides biological healing.[13] The wound was washed thoroughly, along with the local instillation of antibiotics to prevent infection. A bone graft was harvested ipsilaterally from the iliac crest and layered across the fracture site after raising the osteoperiosteal flap. The wound was closed in layers after meticulous haemostasis. The antiseptic dressing was done, and a compression bandage was applied.

Intraoperative blood loss was measured by the mopping method. Only a dry mop was used. Based on the weight that the mop had gained, blood loss was determined.[14] Any intra-operative complication was noted. A post-operative X-ray was done. Wound inspection was done on the 3rd postoperative day or earlier if soakage occurred. Sutures were removed on the 12 to 14th postoperative day. During post-operative period, the patient operative limb was kept at 90^0 of knee flexion. Full weight bearing with walker-aided ambulation was done earliest as possible (even the next day), as per the patient's pain tolerance. Gradually patients were shifted to walking sticks at 6 weeks. Patients were followed up in Orthopaedics OPD at 2, 6, 12 weeks, 6 months, and 1 year. At every follow-up visit, patients were assessed clinically and with an X-ray of the involved thigh with hip, and knee to assess union, functional outcome, and complication. Union of fracture was defined clinico-radiologically as the presence of a bridging callus (callus appearance on three or four cortices on anteroposterior and lateral radiograph views[15]), the number of bridged cortices, disappearance of fracture lines, absence of pain or tenderness at the fracture site during weight-bearing.[16,17] Functional outcome at each follow-up visit was accessed by using Neer's knee score.[18]

RESULTS:

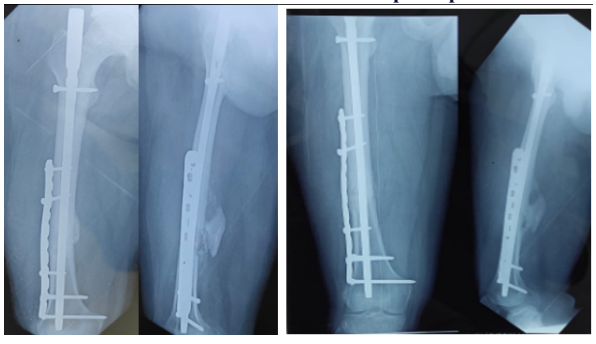
Pre & intra-operative variables

Variables	Nail-plate construct (n=12)
Mean age	45.8 years
Gender distribution	Male- 9; Female- 3
Side of involvement	Left- 8; Right- 4
Mode of injury	High energy injury- 8; Low energy injury- 4
Length of incision	10.5 cm
Mean duration of surgery	105.2 minutes
Average blood loss	110 mL

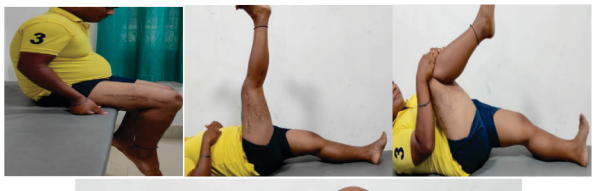
Post-operative variables

Variables	Nail-plate construct (n=12)	
Mean time to union	14.6 weeks	
Neer's knee outcome	At 6 months- 75% Excellent, 16.7% Good 8.3% Fair At 1year- 91.7% Excellent, 8.3% Good	
Knee flexion	At 6 months	At 1 year
	>120°-8 > 90°-3 > 70° -0 < 70° -1	>120°-9 > 90°-2 > 70° -1 < 70° -0
Complications	Superficial infection - 3 Deep infection - 1 Malunion - 0 Delayed union - 1 Nonunion - 0	

Nonunion **Immediate post-op**



At 6 months **At 1 year follow up**



At 1 year follow up clinically

DISCUSSION:

Internal fixation is preferred over non-operative treatment for distal femoral fractures.[12] Nonunion is not so uncommon in junctional area distal femur fractures. Inadequate reduction, implant failure, bone resorption, spacious distal medullary canal, an undersized nail, inefficacy of distal locking screw, and residual rotational instability are the causes of nonunion.[19,20.] Various methods of treatment have been described, such as dynamic condylar screw and plate, distal femoral locking plating, exchange intramedullary nailing, and augmentation plating. Exchange nailing (replacement of intramedullary nail by a larger diameter nail via 1-3mm over-reaming of medullary cavity) is recommended in the treatment of aseptic nonunion of junctional distal femur fractures. Despite of 90% union rate, there is still a potential chance of nonunion in the modern healthcare system.[21] The residual

rotational instability is the main reason for hypertrophic nonunion in cases of intramedullary nailing and exchange nailing.[11]

According to a study by Chi-Chuan Wu et al., exchange intramedullary nailing along with augmented cancellous bone grafting is a reliable method in the management of aseptic femoral nonunion.[10] According to the study by Mahmoud et al., it was concluded that both the methods exchange nailing along with bone grafting, and plate augmentation are equally sufficient in the management of aseptic femoral union.[22] According to the study by Anshul Sethi et al., it was concluded that exchange nailing along with plate augmentation is effective in the management of aseptic nonunion of junctional distal femur fractures.[20] According to the study by Ashok Sharma et al., it was concluded that the Nail-plate combination is effective in the treatment of junctional distal femur fractures.[12] In our study we did antegrade nailing along with plate augmentation with autologous graft from the ipsilateral sided iliac crest. We used NEER score to quantify functional outcome of patients. The main goal of our treatment is to achieve stable fixation, anatomical reduction, and restoration of limb alignment, length, and rotation, followed by early union and mobilization.

The biomechanical advantage of nail plate construct is mainly due to the dual advantages of both intramedullary nail and plate. Axial and bending stability provided by the intramedullary nail along with its load sharing property, distributes the forces thus allowing early weight bearing. The plate provides antirotational stability and compression, promoting the union. The linkage of nail and plate distally reinforces the construct, making it a single unit. Spanning the entire length of femur allows for a smoother distribution of forces. The use of mini-open and minimally invasive techniques causes less soft tissue dissection and less blood loss, thus resulting in better healing.[23,24,25]

We conducted a study on 12 patients with aseptic nonunion of junctional area distal femur fractures from April 2020 to September 2022; and attempted to survey, evaluate, document, and quantify the results in terms of perioperative measures, fracture union, range of knee movement, functional outcome, and complications. There were only 4 cases of nonunion of junctional area distal femur fracture initially treated with an intramedullary device or plate in the study. There were 8 untreated cases of nonunion of junctional area distal femur. Due to covid-19 pandemic, a large number of patients had their surgeries delayed or postponed and could not receive any operative treatment. Several such patients presented very late, seeking treatment to our OPD after the waning of multiple waves of covid. There were 9 males and 3 females in our study. Altogether, 8 patients (67%) sustained these fractures due to high-energy injuries like RTA and 4 patients (33%) sustained them due to low-energy injuries (like domestic self-falls). A total of 4 patients (33.3%) had right-sided fractures, and 8 patients (66.7%) had left-sided fractures.

The mean age of our study was 45.8 years. The mean duration of surgery was 105.2 minutes, with a mean length of incision of 10.5 cm. The mean blood loss was 110 mL. The average follow-up period was 12 months. The average time for fracture healing was 14.6 weeks. The average range of knee flexion was 110.8^0. Good-excellent knee functional outcome was 91.7% at 6 months of follow-up, and 100% at the end of 1 year. Raising osteoperiosteal flaps around the nonunion site helped increase surface area of decortication, exposure of vascular subcortical Haversian system, and enhance osteogenic inflammation. Additionally, iliac crest bone grafting also helped in enhanced union.[26]

There were 3 cases of superficial infections, which were managed conservatively with adequate antibiotic coverage (as per the culture and sensitivity report). 1 case had a deep infection which was managed with wound debridement and adequate antibiotic coverage, and had delayed union, which united at 26 weeks. There was no case of screw loosening, implant breakage, rotational malalignment, or shortening.

Comparison with other studies:

Studies	Sample no.	Results
Anshul Sethi et al20 (2021)	10	Union at 7.05 months Average range of knee flexion- 115^0
Chi-Chuan Wu10 (2022)	41	Union at 3.4 months 92.7% Good-excellentknee outcome
Mahmoud et al22 (2022)	12	Union at 6.4 months Average range of knee flexion- 120^0
Ashok Sharma et al12 (2022)	16	Union at 14.75 weeks Average range of knee flexion- 114^0 93.75% Good-excellentknee outcome Delayed union- 1
Our study (2020-2022)	12	Union at 14.6 weeks Average range of knee flexion- 110.8^0 100% Good-excellentknee outcome Delayed union – 1 Superficial infection- 3; Deep infection- 1

Limitations and recommendations:

There are many limitations to this study, including small sample size, shorter duration of follow-up, and lack of any statistical verification. Large, double-blind, and randomized prospective trials are needed to verify the long-term results. The drilling for the screws on the plate with the nail in situ is technically demanding. Further, the cross-linking of the nail plate construct by putting the distal locking screw of the nail through the plate hole into the nail can be very challenging and has a steep learning curve. We recommend that new implants with attachments and zigs for such endeavors be researched and designed in the future.

We also recommend raising osteoperiosteal flaps in aseptic nonunion scenarios, along with cancellous bone grafting, so as to improve biology and achieve early union. Mini-open and minimally invasive techniques should be preferred over extensive dissection for better preservation of soft tissue. Judicious application of robust and stable constructs such as nail plate constructs, which allow the earliest weight bearing in the post-operative period, helps in gaining the patient's confidence and motivation for early mobilisation.

CONCLUSION:

This study concludes that the Nail plate construct is a safe and viable alternative treatment modality for aseptic non-union of distal femoral junctional fractures. It combines the advantages of both intramedullary nail and plate to achieve fracture union along with the earliest possible weight bearing in the immediate post-operative period. The nail provides axial and bending stability at the fracture site, whereas the plate provides antirotational stability and compression, thus providing adequate mechanical stability at fracture site which promotes union. Raising osteoperiosteal flaps and autologous bone grafting enhance biological healing. The stability of such robust construct allows confident earliest weight bearing in the immediate post-operative period, motivates the patient, and leads to early mobilisation leading to good knee function. Hence, we conclude that the nail-plate construct is an optimum method for achieving enhanced fracture healing in aseptic nonunion of the distal femur junctional fractures.

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