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Original Article

Evaluation of results of open distal femur fractures with primary fixation and antibiotic impregnated collagen

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ABSTRACT

Purpose: Distal femoral fracture is one of the most common lower limb injuries and accounts for less than 1% of all fractures. Open fracture takes 5%–10% of the all distal femoral fractures, which is at an increased risk of complications. There were limited studies which documented the outcomes of such cases. The present study aims to evaluate the outcome and complications in these fractures using primary definitive fixation with condylar locking plate and antibiotic impregnated collagen sheet secondary to aggressive debridement.

Methods: This is a prospective study conducted in a tertiary care orthopaedic hospital in northern India. Thirty patients of open distal femoral fractures were managed by primary definitive fixation with condylar locking plate and antibiotic impregnated collagen sheet secondary to aggressive debridement. They were followed for minimum of six months. Patients were followed up monthly for first four months, at six months and one year after surgery. Clinical and radiological signs of healing, any complications, time to union, and functional outcome were assessed.

Results: The mean age of patients was 44.33 years (range 20–82 years) with male predominance of 66.7%. According to Gustilo–Anderson classification, there were 5, 15 and 10 patients with open grade I, II and IIIA distal femoral fractures respectively. According to orthopaedic trauma association (OTA) classification, majority of patients in our study were of C3 type. The mean time to bony union was 5.6 months (range 4–9 months). Average postoperative knee range of motion (ROM) at the latest follow-up was 98° (range 70°–120°). Lysholm knee scoring scale showed excellent score in 11 patients, good in 9 patients, fair and poor in 5 patients each; however, there was no significant correlation with fracture pattern types ($p < 0.05$). Knee stiffness was the major complications encountered in the study. The knee ROM was $< 90^\circ$ in 5 patients and 90° – 120° in rest of the patients, while 1 patient had extensor lag of 10° . One patient had implant failure and lost to follow-up; 3 patients had deep infection.

Conclusion: An approach of primary definitive fixation with condylar locking plate and antibiotic impregnated collagen sheet secondary to early aggressive debridement in open distal femur fractures shows significant results in terms of functional and radiological outcomes with minimal complications.

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Introduction

Distal femoral fracture is one of the most common lower limb injuries encountered in day to day emergency. It accounts for less than 1% of all fractures, of which approximately 5%–10% are open

fractures.^{1,2} Open fractures of distal femur are at an increased risk of complications, especially infection, non-union, knee stiffness and loss of range of motion (ROM).³ Supracondylar femoral fractures show bimodal age distribution, young patients involving in high energy injuries (road traffic accidents, sports injuries) and elderly women involving in low energy injuries (osteoporosis).⁴ Few studies have given emphasis on aggressive debridement and primary fixation in open fractures, also rarely known regarding the optimal management in these kind of injuries.⁵ Historically, open, unstable and intra-articular comminuted distal femoral fractures

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have been known to impose challenges to the surgeon due to juxta articular location causing functional disability to knee joint. With advances in locking plate and fixed angle construct, rigid fixation is possible without secondary loss of reduction and without the need of bone grafts permitting early knee mobilisation.

Aim of the present study is to evaluate the outcome and complications in these fractures using primary definitive fixation with condylar locking plate and antibiotic impregnated collagen sheet secondary to aggressive debridement. We hypothesized that primary definitive fixation with condylar locking plate and antibiotic impregnated collagen sheet secondary to aggressive debridement in open distal femur fractures provide good outcome in terms of union, wound healing and knee range of motion.

Methods

This study was a prospective analysis of patients undergoing primary fixation for open distal femur fractures from March 2017 to February 2019 at a tertiary care centre. All open distal femur fractures in our study were classified according to orthopaedic trauma association (OTA) classification and Gustilo–Anderson classification.^{6,7} Patients aged above 18 years with open comminuted distal femur fractures without bone loss up to grade IIIA, presenting within first 24 h were included in the study. Patients with head injury, neurovascular injury, metastatic disease and patients with less than 6 months follow-up were excluded.

A total of 30 patients who fulfilled the inclusion criteria were included. All patients presented to emergency were haemodynamically stabilized and thorough extensive wash was done at first inspection and limb was immobilized. All patients received intravenous (IV) triple antibiotics in the form of Ceftriaxone 1 g, Amikacin 500 mg and Metroglol 500 mg in standard doses on admission. Patients underwent orthogonal radiographs of the knee with thigh and hip, routine pre-anaesthetic investigations and were taken up for surgery after due informed consent, pre-anaesthetic fitness with adequate blood and blood products within 24 h.

Patients were operated under appropriate anaesthesia in supine position on a radiolucent table under image intensifier. Incision and approach to distal femur varied with the location of the open wounds which were liberally extended proximally and distally, except in cases of medial wound where the wound was extended for debridement only and standard lateral or modified swash-buckler approach was used in such cases.⁸ Second inspection of the wound and radical debridement consisting of excision of devitalized tissues was done preserving the soft tissue envelope

followed by definitive fixation with condylar locking plate following the principles of biological fixation.

We used antibiotic (Gentamicin) impregnated collagen sheet in all cases without primary bone grafting. Physiotherapy was started from day 2 in the form of quadriceps and hamstring exercises and gentle knee ROM up to tolerance. All patients were given 2 weeks of IV and oral antibiotics. The follow-up of patients was done at 2 weeks, 6 weeks, 12 weeks, 6 months and 12 months and six monthly thereafter. Protective weight bearing was allowed based on signs of healing on serial radiographs of follow-up. Parameters assessed were Lysholm knee scoring scale, Neer score, clinical examination of suture line and open wound, knee ROM, knee stability and radiographic evaluation for union, consolidation.^{9,10} Union was defined when at least 3 cortices in orthogonal views showed signs of trabeculae across the fracture site.

Results

Most common cause of fracture in our study was road traffic accident. The mean age of the study population was 44.33 years (range 20–82 years) with male predominance of 66.7%. According to Gustilo–Anderson classification we had 5, 15 and 10 patients with open grade I, II and IIIA fractures, respectively. According to OTA classification, majority of patients in our study were of C3 type. We had 1, 2 and 3 patients of type A1, A2 and A3 respectively, 1 of type B1, 8 of type C2 and 15 of type C3. There were 3 diabetic patients, 1 hepatitis c virus (HCV) positive, 1 hepatitis B surface antigen (HBsAg) positive and 13 smokers in our study; however, there was no statistical significance between co-morbidities and rate of union (Table 1).

Average time between trauma and definitive fixation was 15.9 h (range 12–24 h). Average length of hospital stay was 8.06 days (range 6–18 days). The mean time to bony union was 5.6 months (range 4–9 months). Primary union was achieved in 17 patients, delayed union in 9 and nonunion in 4, with no statistical difference between time for bony union and various grades of Gustilo–Anderson classification included in the study (Table 2) (Fig. 1A–1H). The mean time to follow up was 14.1 months (range 6–23 months). Neer score showed excellent results in 11 patients, good in 9, fair and poor in 5 each; however, there was no significant statistical correlation between Neer score and Gustilo–Anderson grading of open fractures included in the study (Table 3).

Average postoperative knee ROM at the latest follow-up was 98° (range 70°–120°). Partial protective weight bearing was allowed after 3 months and full weight bearing was achieved in

Table 1
Correlation between union and co-morbidities and risk factors.

Co-morbidities and risk factors	n (%)			p value	Chi-square	df
	Primary union	Delayed union	Non-union			
Diabetes	1 (33.3)	1 (33.3)	1 (33.3)	0.245	5.436	4
HCV/HBsAg positive	0 (0)	2 (100.0)	0 (0)			
Smoker	8 (61.5)	3 (23.1)	2 (15.4)			

HCV: hepatitis c virus, HBsAg: hepatitis B surface antigen.

Table 2
Association between open fracture grades (Gustilo–Anderson classification) and status of union.

Gustilo–Anderson grade	n (%)			p value	Chi-square	df
	Primary union	Delayed union	Non-union			
I	4 (80.0)	1 (20.0)	0 (0)	0.63	2.556	4
II	9 (60.0)	4 (26.7)	2 (13.3)			
IIIA	4 (40.0)	4 (40.0)	2 (20.0)			



Fig. 1. A 25 year old male patient presented with open grade IIIA and 33C3 OTA type distal femur fracture of right side. (A, B) Preoperative radiographs of orthogonal views; (C, D) Postoperative radiographs at 3 months follow-up; (E, F) Post-operative radiographs at 15 months follow-up showing bony union; (G, H) ROM of knee at latest follow-up.

all patients by 6 months. Lysholm knee scoring scale showed excellent score in 11 patients, good in 9, fair in 5 and poor in 5; however, there was no significant correlation with fracture pattern types ($p < 0.05$) and the scores were maintained in all patients at the final review of minimum 6 months (Table 4). Activities of daily living were restored in majority of patients except

for squatting and cross leg sitting which was discouraged by us to prevent complications (Fig. 1G and 1H).

Knee stiffness was the major complication encountered in the study. The knee ROM was $<90^\circ$ in 5 patients and $90-120^\circ$ in the rest of them, while 1 had extensor lag of 10° . One patient had implant failure and lost to follow-up (Fig. 2A–2D), 3 had deep infection

Table 3

Association between open fracture grades and Neer score outcome at latest follow-up.

Gustilo-Anderson grade	Neer score, n (%)				p value	Chi-square	df
	Excellent	Good	Fair	Poor			
I	3 (60.0)	1 (20.0)	0 (0)	1 (20.0)	0.661	4.114	6
II	5 (33.3)	5 (33.3)	4 (26.7)	1 (6.7)			
III A	3 (30.0)	3 (30.0)	1 (10.0)	3 (30.0)			

Table 4

AO/OTA classification and Lysholm knee scoring scale.

AO/OTA classification	Lysholm knee scoring scale at final follow-up (n)				p value	Chi-square	df
	Excellent	Good	Fair	Poor			
A1	1	0	0	0	0.7	11.71	15
A2	2	0	0	0			
A3	2	1	0	0			
B1	1	0	0	0			
C2	2	3	2	1			
C3	3	5	3	4			

within 2 weeks of surgery that underwent sequential and aggressive debridement along with IV antibiotics based on culture and sensitivity. Delayed union was observed in these patients along with remissions and exacerbations of infection for which implant removal was done at an average of 18 months. No surgical intervention was done in remaining patients (Table 5).

Discussion

Distal femur fractures are usually high velocity injuries compounded by intraarticular comminution, ligamentous injury and open wounds. These open fractures are associated with high complication rates causing infection, malalignment and post traumatic osteoarthritis.¹¹ Aggressive wound debridement and thorough lavage represents an important part of treatment for patients with open fractures. However, inadequate debridement can cause infection while overly aggressive debridement can lead to non-union.¹² With the advent of locking plates and fixed angle screws the treatment of distal femur fractures has been demonstrated to be successful without the need for bone graft.^{13,14} Although locking

Table 5

Complications observed in the cohort (n = 30).

Complications	n (%)
Infection	3 (10.0)
Delayed union	9 (30.0)
Nonunion/implant failure	4 (13.3)
Knee stiffness	5 (16.7)
Extensor lag	1 (3.3)

plates have shown good results for closed distal femur fractures, the use of the same has been limited in cases of open fractures. Also very few studies in literature have done primary fixation in open distal femur fractures.^{5,12,15} In this study we have recorded optimal union rates with excellent to good functional and radiological outcome by primary fixation using locking plate and antibiotic impregnated collagen sheet. Our approach of aggressive debridement and early primary fixation while respecting soft tissue envelope around the joint made us successful in preventing from infection, achieving union and good knee ROM with minimal complications.

The initial care of aggressive debridement and the timing of definitive fixation in open fractures are arguable and controversial.¹⁶ In the current study, the strategy of aggressive debridement and primary fixation along with antibiotic impregnated collagen sheet was used, which resulted in good to excellent clinical and functional outcome in majority of our patients. The protocol of primary debridement at the scene of the accident and emergency department operation theatre and subsequent debridement and definitive fixation in the main surgical operation theatre within 24 h gave us advantage of minimising deep infection; while the strategy of locking plate in these comminuted fractures provided healing, prevented varus collapse without the need for bone



Fig. 2. A 53 year old female patient presented with open grade IIIA and 33A3 OTA type distal femur fracture of right side. (A) Pre-operative radiographs anteroposterior view; (B) Immediate post-operative radiograph anteroposterior view; (C, D) Post-operative radiograph of orthogonal views at 6 months follow-up showing implant failure and non-union.

grafting. Our findings were similar to the study done by Barei et al.⁵ They did acute open reduction and internal fixation in 8 patients for open grade IIIA and above distal femur fractures.⁵

Dugan et al¹⁵ treated 15 patients with open grade IIIA and IIIB supracondylar femur fractures types C2 and C3 in 2 stages. Stage 1 consisted of thorough open fracture care and definitive fixation with a lateral locking plate within 24 h along with antibiotic bead placement. Stage 2 was done months later for bone grafting, bone morphogenetic protein and additional medial column plate. They reported union in all 15 patients with knee stiffness as common complication and no deep infection or malalignment. Our study was in concordance with the findings of serial debridement and union with primary locking plate fixation. We believe lateral locking plate is biomechanically strong enough to prevent varus collapse despite medial comminution without the need for bone graft; serial debridement with antibiotic impregnated collagen sheet prevents deep infection and provides similar results. We also agree with the findings of knee stiffness as a common postoperative complication among patients for which stable rigid fixation and early mobilisation of knee is recommended.

In a retrospective cohort study by Hoffmann et al¹¹, 24 patients underwent locked plate fixation for open distal femur fractures. They reported open grade I and II fractures healed at a significantly higher rate as compared to type grade III open fractures. They also report greater percentage of healing for closed fractures compared to open fractures.¹¹ In our study, similar findings were observed in majority of patients of grade II and grade IIIA fractures.

Knee stiffness was seen in 5 patients postoperatively, in whom the knee ROM was <90° at the latest follow-up. Aggressive physiotherapy and continuous passive movement was advised. However, these patients were able to do activities of daily living except for squatting and cross legged sitting. Our findings were contradictory to other studies in literature which shows non-union, delayed union and implant failure to be more frequent.¹⁷

Several limitations of present study should be considered, small sample size without control group or randomization which may have introduced bias in our study. Other limitation of the procedure is that it cannot be applied in the fractures associated with the extensive bone and soft tissue loss requiring bone and soft reconstructive procedures, as bone cortical continuity in one or more plane is required for the success of the current procedure. In these cases two staged procedure or other methods of management may be used. Furthermore, all surgeries were done by a single, experienced surgeon of a level 1 trauma center. A multicentre study with a longer follow-up is necessary to evaluate the results and strengthen our findings.

Preservation of osseous and soft tissue vitality along with thorough debridement and early rigid stabilisation are the key points of success in the procedure described in the present study. Rigid biomechanical environment has been shown to be integral for bone and soft tissue healing.^{15,18} We agree with Pape et al.¹⁸ that early skeletal stabilisation and open fracture care stops the cycle of injury, removes nidus for infection, and halts on-going haemorrhage. All these factors also help in minimising complications of infection, mal-union, non-union, and implant failure associated with other procedures.

An approach of primary definitive fixation with condylar locking plate and antibiotic impregnated collagen sheet secondary to early aggressive debridement in open distal femur fractures shows significant results in terms of functional and radiological outcome with minimal complications. The locking plate provides stable rigid fixation while awaiting union and allows early knee ROM. However

the selection of patients and timing of internal fixation is important in these open fractures to minimise complications and failure.

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Ethical statement

This study has been approved by the responsible committee and informed consent has been obtained from all patients or relatives.

Conflicts of interest

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