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Outcome following swashbuckler modified anterior approach versus lateral approach for management of complex distal femur fractures: A prospective comparative study

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Abstract
Background: Distal femur fractures with intra articular extension and comminution are exacting injuries, rife with complications such as malunion and stiffness. We prospectively evaluated and compared a consecutive series of patients with AO type C distal femur fractures to determine the clinicoradiological outcome after fixation with a single locked plate using swashbuckler approach (modified anterolateral) and standard lateral approach.
Materials and Methods: 120 patients with C type distal femur fractures (mostly type C2 and C3) were treated with distal femur locking compression plate (DF-LCP), 60 using swashbuckler approach and 60 using standard lateral approach, were included in the study. The clinical outcome at 1 year was determined using the Neer's Score.
Results: All fractures united at a mean of 14.64 weeks (range 12-20 weeks). In our study mean duration of surgery for lateral approach group was greater (99.6min) than swashbuckler group (85min).There were no significant complications such as nonunion, deep infection, and implant failure. Mean ROM in swashbuckler group was 100.83 degree compared to 83.83 in lateral group. Mean Neer's score was 76.96 in lateral approach group compared to 81.83 Neer's score in swashbuckler approach. Excellent results were seen in 19 cases (63.3%) in swashbuckler group as compared to 13 cases (43.3%) in lateral approach group.
Conclusion: The results of complex C type distal femur fractures, fixed with a single distal femur locking compression plate (DF-LCP) using a swashbuckler approach as compared to standard lateral approach are affirmative and comparable with a majority of patients achieving good to excellent outcome at 1 year especially in complex C3 fractures.

Keywords: Distal femur fracture, complex distal femur fractures, intra articular distal femur fractures, swashbuckler approach, standard lateral approach, distal femur locking compression plate

Introduction
Distal femoral fractures account for approximately 6% of all femoral Fractures [1]. A classic bimodal distribution exist with one peak in incidence in young men (15-30 years) and elderly women (>70 years). Young patients are affected by high velocity trauma (including motor vehicle accident, motorcycle or sports injury) and elderly are predisposed to low energy fracture due to osteoporosis [2]. Intra-articular fractures of the distal part of the femur are difficult to treat and present considerable challenges in management [3]. Treatment modality for fractures has been changed with advancement of medical sciences. The trend of open reduction and internal fixation has become evident in the recent years with good results being obtained with locking compression plate [4]. Multiple surgical approaches have been described previously to obtain a good exposure of distal femoral articular surface, including medial parapatellar approach, 5 lateral parapatellar (anterolateral) approach [6] tibial tubercle Osteotomy [7 8], and combined medial and lateral approaches [9] The latter two approaches are too extensive and frequently lead to complications, such as delayed wound healing, flap necrosis and delayed healing of osteotomy. The parapatellar approaches provide a sufficient articular exposure but involve splitting of the quadriceps mechanism, which may lead to

scarring or adhesions. Moreover, they are difficult to extend proximally, if open compression plating of the extra-articular fracture is planned. The proximal extension of a medial parapatellar approach, as described by Henry, [10] involves cutting through the rectus tendon, which may not be desirable. Starr *et al*. [11] described a modified anterior "swashbuckler" approach to the distal femur, which facilitated complete exposure of distal femur articular surface and quicker rehabilitation.

Aims and Objectives

To evaluate and compare the radiological and functional outcome of patients treated with modified anterior approach (swashbuckler approach) and lateral approach for management of distal femur fractures.

Materials and Methods

This prospective study was conducted at a tertiary health care center at Sir Gangaram Hospital, New Delhi between June 2017 and October 2018. The study was approved by the Institutional ethics committee and a written informed consent was obtained by all participants. The study included 60 patients with supracondylar fracture of femur with intra articular extension who underwent open reduction and internal fixation (ORIF) with locking compression plate (DF-LCP) either by standard lateral approach (Group A) or Modified Anterior Approach (Swashbuckler approach Group B) and followed up for 6 weeks, 12 weeks and 24 weeks at our institute.

Adult Patients were included with closed fractures of Type C. Those with Pathological fractures, Other associated skeletal injury, Poly Trauma patients, Compound Fractures, Patients Treated conservatively, AO type A and B Patients who were bedridden or non-ambulatory, Patients with severe life threatening medical problems, were excluded.

The age group included in our study ranged from 18-65 years, with a mean age of 36.01 years. There were 55 (91.67%) males and 5 (8.33%) females.. Predominant lower limb involved was right side accounting for 44 cases (73.3%) and remaining 16 cases (26.7%) were left sided fractures.

There were 50% AO type C3 and 41% AO type C2 fractures. This pattern confirms to the high velocity injuries being commonly associated with AO type C. Mean duration of the surgery after injury was 6.1 days ranging from 2 days to 16 days.. All cases were performed under spinal anesthesia either SAB or CSE in supine position with a roll or triangle under the operating knee. 30 were operated with standard lateral approach (Group A) and 30 with Modified Anterior approach (Swashbuckler approach Group B). Image intensifier was used intra-operatively with fixation using distal femur locking compression plate in all patients.

Lateral Approach

The incision is made directly laterally in the thigh and through the midpoint of the lateral condyle distally while staying anterior to the proximal insertion of the lateral collateral ligament. Proximally, the incision is extended as necessary for diaphyseal involvement of the supracondylar fracture. The distal incision can be extended so that it gently curves from the knee joint axis anteriorly to the lateral border of the tibial tubercle when the fracture involves the articular condyles. The fascia lata is incised in line with the skin incision, and its fibers are split. Distally, it is often necessary to incise the anterior fibers of the iliotibial tract, and the incision is then carried down through the capsule and synovium on the lateral aspect of the lateral femoral condyle.

Care must be taken to identify the superior lateral geniculate artery, which must often be ligated, and to avoid damage distally to the lateral meniscus. To expose the articular surface, a blunt Hohmann retractor is placed across the joint and over the medial femoral condyle.

Visualization of the articular surfaces of the lateral condyle is usually adequate. The medial condyle, especially its posteromedial aspect, is difficult to visualize. Osteotomy of tibial tubercle and lifting along with patellar tendon improved anterior exposure to the condyles of femur.

To expose the distal femoral shaft, the vastus lateralis muscle must be reflected off the lateral intramuscular septum. Care must be taken to identify and ligate the perforating vessels. It is only necessary to expose enough of the lateral cortex to apply the plate. Any additional unnecessary soft tissue stripping or the careless insertion of anterior or posterior retractors should be avoided.

Swashbuckler Approach to the Distal Femur [11]

Place the patient supine, preferably on a radiolucent table. Use a sterile tourniquet only if necessary to avoid medial retraction of the quadriceps. Place a roll or triangle under the knee. Make a midline incision from above the fracture laterally to across the patella. Extend the incision directly down to the fascia of the quadriceps. Incise the quadriceps fascia in line with the skin incision. Sharply dissect the quadriceps fascia off the vastuslateral is muscle laterally to its inclusion with the iliotibialband. Retract the iliotibial band and fascia laterally, continuing the dissection down to the linea aspera. Incise the lateral parapatellar retinaculum, separating it from the Vastus lateralis. Make a lateral parapatellar arthrotomy to expose the femoral condyles. Place a retractor under the vastus lateralis and medialis, exposing the distal femur and displacing the patella medially Ligate the perforating vessels, and elevate the vastus lateralis, exposing the entire distal femur. Proceed with the internal fixation as needed. Close the wound by suturing the fascia back in place.

Post operatively the limb was kept in BB splint to prevent contracture of the quadriceps. Quadriceps exercises and hamstring exercises were started on First post-operative day depending on fixation, stability and fracture configuration. After quadriceps and hamstring strengthening exercises, active and active assisted range of motion exercises of the knee were initiated. Patients were discharged after stoppage of parenteral antibiotic once wound was dry and healthy and in case of unstable fractures patients were discharged with long knee brace for 3-5 wks. Patients were followed up on 6 weeks and 12 weeks and 24 weeks followed by 12 months. On follow up, all patients were assessed using Neer's Criteria for functional outcome [12].

It consists of: Functional (70 units) and Anatomic (30 units). The results were evaluated by taking into consideration the following factors:

1. Pain - 20 points
2. Function - 20 points
3. Motion - 20 points
4. Work - 10 points
5. Gross Anatomy - 15 points
6. Roentgenograms - 15 points

Neer' s Score	Over All Ratting
Excellent	Above 85
Good	70-85
Fair	55-69
Poor	Below 55

The fracture was considered united, if there were no pain on palpation or attempted motion, no discomfort on full weight bearing and serial roentgenograms demonstrating circumferential callus formation at fracture site. The functional and radiographic results were recorded according to Neer's criteria. Functional grading was made depending on pain, walking capacity, mobility and work. Radiological grading was made based on varus or valgus deformity, shortening, signs of Osteoarthritis and union of fracture. Partial weight bearing with early signs of clinically and radiological of union. Patient follow up depended on the clinical examination as well as the x-ray findings.

Results and Conclusion

In our study we treated 60 fractures of distal femur belonging to type C of AO Muller classification. We evaluated the results of radiological union and functional outcome in these fractures using Neer's Scoring criteria. We used distal femur locking compression plate (DF-LCP) for fixation via a conventional lateral approach for 30 patients and modified Anterior (swashbuckler) approach for other 30 patients. The age group included in our study ranged from 18-65 years, with a mean age of 36.01 years. There were 55 (91.67%) males and 5 (8.33%) females. Predominant lower limb involved was right side accounting for 44 cases (73.3%) and remaining 16 cases (26.7%) were left sided fractures. There were 50% AO type C3 and 41% AO type C2 fractures. This pattern confirms to the high velocity injuries being commonly associated with AO Type C. Mean duration of the surgery after injury was 6.1 days ranging from 2 days to 16 days. All cases were performed under spinal anesthesia either SAB or CSE.In our study mean duration of surgery for lateral approach group was greater (99.6min) than swashbuckler group (85 min). Local complications were persent in 13 (21.6%) patients. They included restriction of knee movements (6 patient) with 5-10^0 terminal extension lag in two patients, chronic swelling of injured lower limb (1 patient), and superficial infection (2 patients), Restriction of movement is common complication of Distal femur fracture. Over all complications in our study was less but comparatively more in patient treated by Lateral approach. The average time to union was 3.66 months (14.64 weeks) with a range of 3 – 5 months (12-20 weeks). Follow up of our cases included from a minimum of 6 months to a maximum of 12months. Mean Neer's score was 76.96 and standard deviation was 8.54 in lateral approach group compared to 81.83 Neer's score and 11.16 standard deviation in swashbuckler group. Excellent results were seen in 19 cases (63.3%) in swashbuckler group as compared to 13 cases (43.3%) in lateral approach group which was significant.

Table 1: AGE Distribution

Age Group In Year	No. of Patients	No. of Patients		Pateints Age %	Pateints AGE %	Total Pateints Age %
	Group A	Group B	Group (A+B)=C	Group A	Group B	Group (A+B) = C
18-30	11	15	26	36.67	50.00	43.33
31-40	9	3	12	30.00	10.00	20.00
41-50	8	7	15	26.67	23.33	25.00
51-60	1	5	6	3.33	16.67	10.00
61-70	1		1	3.33	0.00	1.67
Total	30	30	60			
Mean Age				36.23	35.8	36.015

Table 2: Sex Distribution

Sex	No. of Patients	No. of Patients		Pateints%	Pateints%	Total Pateints %
	Group A	Group B	Group (A+B) = C	Group A	Group B	Group (A+B)=C
Male	26	29	55	86.67	96.67	91.67
Female	4	1	5	13.33	3.33	8.33

Table 3: AO Type of Fracture

Ao Type	No. of Patients	No. of Patients		Pateints%	Pateints%	Total Pateints%
	Group A	Group B	Group (A+B) = C	Group A	Group B	Group (A+B) = C
C1	1		1	3.33	0.00	1.67
C2	19	10	29	63.37	33.33	48.33
C3	10	20	30	33.33	66.67	50.00

Table 4: Duration of Surgery in Minuts

Minuts	No. of Patients	No. of Patients		Pateints%	Pateints%	Total Pateints%
	Group A	Group B	Group (A+B)=C	Group A	Group B	Group (A+B)=C
60 -90 Minuts	13	20	33	43.33	66.67	55.00
90-120 Minuts	11	10	21	36.67	33.33	35.00
> 120 Minuts	6	0	6	20.00	0.00	10.00

Table 5: Time to Union (Union Rate)

Month	No. of Patients	No. of Patients		Pateints%	Pateints%	Total Pateints%
	Group A	Group B	Group (A+B)=C	Group A	Group B	Group (A+B)=C
<3 Month	9	13	10	10.00	23.33	16.67
3-6Month	21	17	38	70.00	56.67	63.33
>6Month	0	0	0	0.00	0.00	0.00

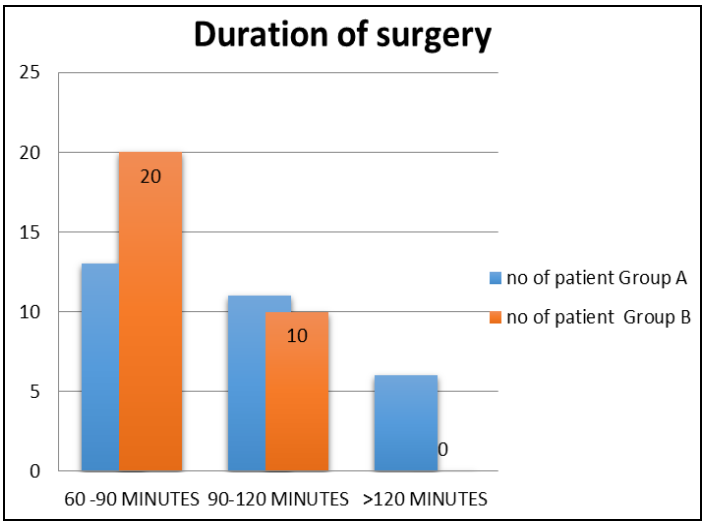


Fig 1: Chart Showing Duration of Surgery

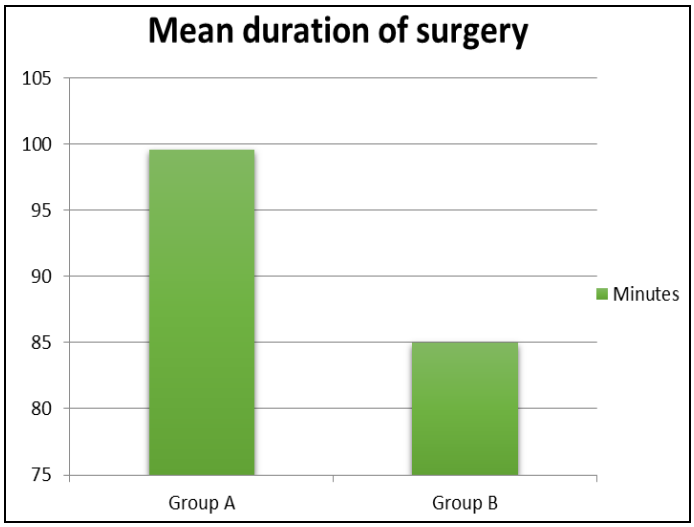


Fig 2: Chart Showing Mean Duration of Surgery

Table 6: Local complications

Local c Omplications	Type of Approach		Total
	Lateral	Swashbuckler	
Restriction of movement	4	2	6
	13.30%	6.66%	10%
Terminal extension lag	2	2	4
	6.66%	6.66%	6.66%
Superfecial infection	2	0	2
	6.66%	0%	3.30%
Chronic swelling of limb	1	0	1
	3.30%	0%	1.70%
No complication	21	26	47
	70%	86%	78%

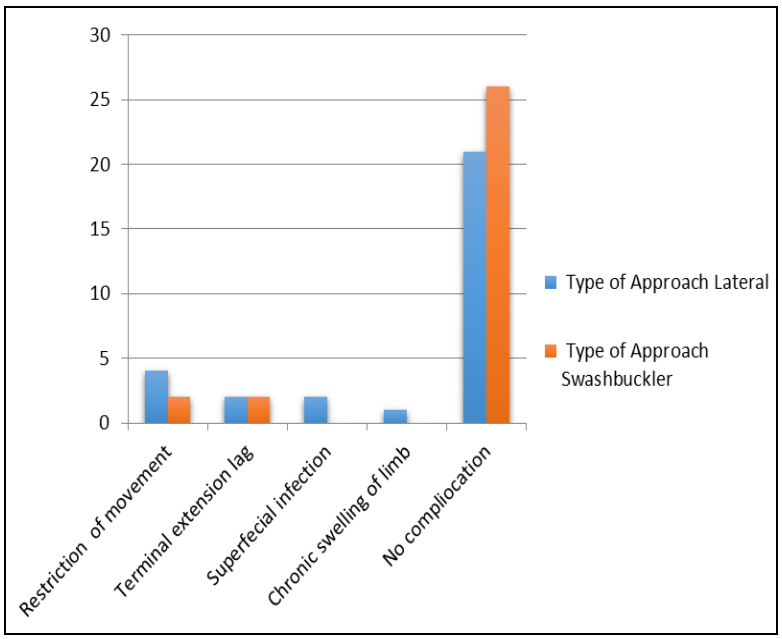


Fig 3: Chart Comparing Complications

Table 7: Neer's score results

Neer's score result	Type of Approach		Total
	Lateral	Swashbuckler	
Excellent	13	19	32
	43.30%	63.30%	53.30%
Good	13	6	19
	43.30%	20%	33.30%
Fair	4	5	9
	13%	16.70%	15%
T0tal	30	30	60
	100%	100%	100%

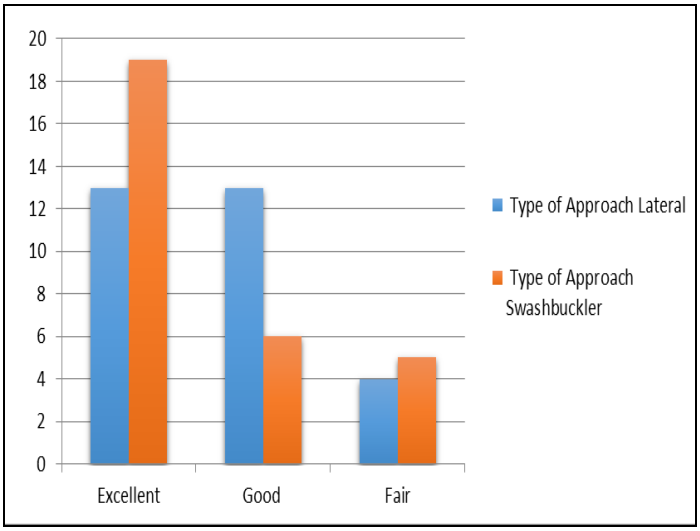


Fig 4: Chart Comparing Neer's Score

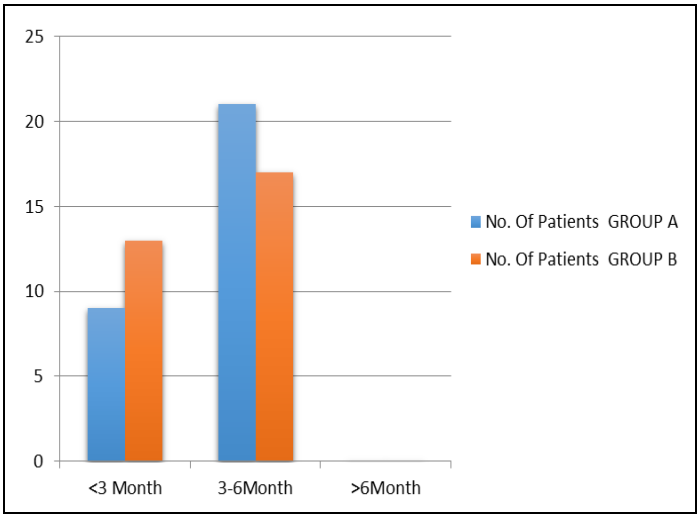
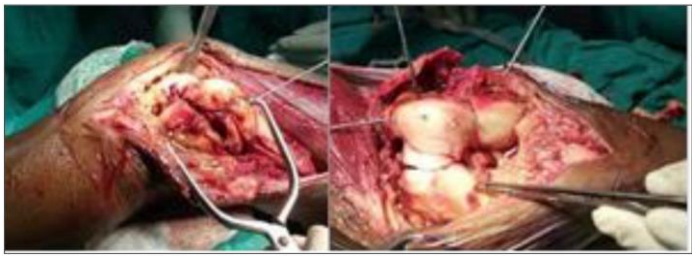


Fig 5: Chart Showing Time Taken For Union

Conclusion

The aim of treatment is to achieve anatomical reduction of articular surface, restoration of the limb length and alignment, as well as allowing for early limb mobilization to avoid articular stiffness and the loss of the muscle mass. Good planning and execution of surgery in complex C3 distal femur fractures results in better functional outcomes on par with other means of fixation even in these intra articular injuries. Reconstruction of distal femur fractures especially in supracondylar and intercondylar fractures is a challenging task. For a better functional outcome proper anatomical restoration and alignment is required which we found in swashbuckler approach as proper exposure of joint is possible which helps to reconstruct the articular surface and maintain the articular congruity which further leads to increase in range of motion as compared to Lateral approach in which proper exposure of joint is not possible. From our study we conclude that results in the two groups are comparable. Swashbuckler is better in terms of anatomical reduction and functional outcome for C3 fractures however for C2 type fractures, we got similar results with both approaches. Any of the two approaches can be chosen as surgeons preference technically we found swashbuckler approach much better for complex C3 type distal femur fractures where intra articular and medial condyle exposures required for visualization of articular fragments for good reduction and rigid fixation. Quadriceps belly is preserved in this approach which benefit to early rehabilitation in the form of good knee range of movement.

Fig 1: Intraoperative Photograph *(Swashbuckler appearance)*



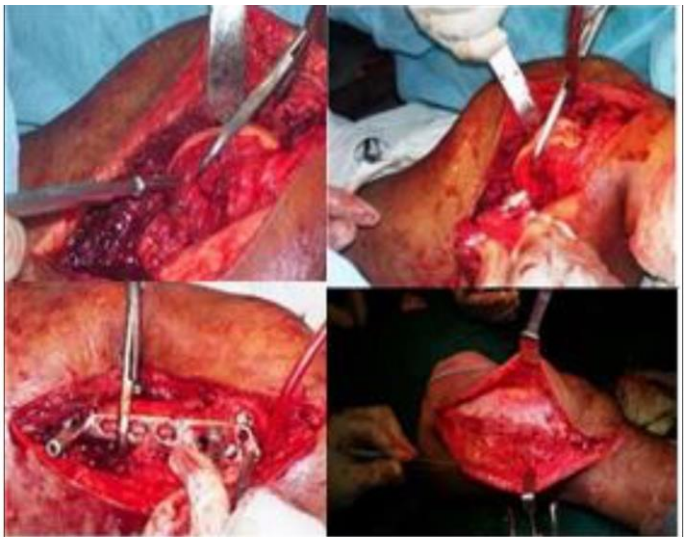


Fig 2: Intraoperative photographs (*Lateral* approach)

Fig 3: 6 month's follow-up clinical photograph

Fig 4: Preoperative radiograph

Fig 5: Postoperative radiograph

Fig 6: 6 month's follow-up clinical photograph

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