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# Experience of Dual Plating in Distal Femur Fractures

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Authors ABS and MF operated on the patients. Author MSH collected and analyzed the data of the patients prior to the surgery as well as after it and drafted the manuscript. All authors contributed to manuscript revisions. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aim of the Study:** Considering above pitfalls of single lateral plating we conducted a study to assess the role of dual plating.
**Study Design:** The study conducted is prospective in nature.
**Place of Study:** Department of Orthopedics, Jawaharlal Nehru Medical College and Hospital (JNMCH), Aligarh Muslim University (AMU), Aligarh.
**Methodology:** We conducted a prospective study from November 2018 to November 2020 on 32 patients. We included the complex extra and intraarticular fractures (A3, C2 and C3 according to the OTA classification) in our study. Standard Antero-Posterior and lateral radiographs of injured distal femur and knee joint were used. We used anterior midline in 19 and dual incision approach in 13 patients. We followed the patients clinically and radiologically for union and knee function by knee society score.
**Results:** Mean age of patients was 46 years (20-65 years). 21 were male and 11 were females. Mean follow up of our patient was 18 months (6-29 months). Fracture union was achieved in 29 out of 32 patients. Average time to achieve union was 9 months (6-14 months). Most of the patient's range of Motion (ROM) was 90°-135°. 24 patients obtained good to excellent results. None of them developed varus or valgus deformity.
**Conclusion:** Considering these covenant results we propose that dual plating is the most appropriate modus operandi for the treatment of the distal femur fractures.

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*Keywords: Dual plating; distal femoral fracture; intraarticular; varus collapse.*

## ABBREVIATIONS

*DFLCP : Distal Femoral Locking Compression Plate*
*AO/OA :Arbeitsgemeinschaft fur Osteosynthesfragen*
*ROM : Range of Motion*
*AP : Antero-Posterior*
*KS S: Knee Society Score*
*DCU : Dynamic Compression Unit*
*RTA : Road Traffic Accident*
*FFH : Fall from Height*
*FOG : Fall on Ground*
*GA : Gustilo Anderson*
*ITBS : Iliotibial Band Syndrome*
*DVT : Deep Vein Thrombosis*
*UTI : Urinary Tract Infection*
*ABP : Angled Blade Plate*
*DCS : Dynamic Condylar Screw*
*PCL : Posterior Cruciate Ligament*
*CPM : Continuous Passive Motion*

## 1. INTRODUCTION

The world is progressing over a rapid speed leading to a massive development in the field of automobiles and land and buildings. But every facet has its own pros and cons.

Although these advancements have made our life easier, but it has led to higher cases of road traffic accidents and construction sites accidents devastating many lives. Most of these patients are young individuals. The older patients sustaining these types of injuries are osteoporotic that too mostly of the female gender. There is a bimodal [1] distribution of the fracture of the distal femur.

The distal femoral fractures pose considerable challenge to the orthopedic surgeon. These injuries particularly those extending into the knee joint lead to considerable functional impairment. They account for 6% [2] of all femur fractures.

Despite the recent advancements in techniques and implants, the treatment of intra-articular multi-fragmentary distal femoral fractures remains a tedious task. The management of these fractures present many difficulties due to the factors like, severe soft tissue damage, fracture extending into the knee joint, marked comminution at the fracture site and injury to the quadriceps mechanism [3].

Long-term disability can occur in patients with extensive articular cartilage damage and marked comminution. Fracture shortening with extension and varus deformities of the distal articular surface is a typical presentation [4].

A variety of nails and plates have been recommended in the past for the fracture of the distal femur. Although intramedullary devices, blade plates and dynamic condylar screws with side plates were commonly used, condylar buttress plates are more useful for very distal fractures and those with intraarticular comminution [5,6,7].

At present the fractures of the distal femur are treated using Distal Femur Locking Compression Plate (DFLCP). It has the advantage of combination of compression plating, locked plating and bridge plating. It results in reduction in soft tissue damage and preserves the periosteal vessels [8].

Single lateral plating of the distal femur fractures high failure rates [9]. A medial plate in conjunction with the lateral plating reduces the chances of failure of fixation [9]. This article focuses on the advantages of dual plating of the distal femur fractures.

## 2. MATERIALS AND METHODS

The study was a prospective one. 32 patients of the fracture of the distal femur were taken in our study form August 2016 to September 2019. They were all managed by dual plating of the distal femur. The study was permitted by the ethical committee of our institution.

The inclusion criteria were patients having A3, C2 or C3 fracture of the distal femur according to the OA classification, closed or compound grade I or II according to the Gustilo Anderson classification, low condylar fractures and fractures less than 3 weeks old. The exclusion criteria were compound grade III(B&C), other ipsilateral fractures and pathological fractures.

There were no intermediate procedures. Dual plating was the only procedure done both in the closed and open injuries be it Grade I or Grade II.

Standard Antero-Posterior and Lateral radiographs of the injured distal femur with the knee joint was taken. Oblique and tractional radiographs were taken, if needed for better

understanding of the fracture geometry. CT scan with 3D-reconstruction was done if needed.

## 2.1 Surgical Technique

After obtaining informed consent and anesthetic fitness the patient was taken up for the procedure. All the procedures were taken under spinal anesthesia.

The surgery was performed in supine position with the knee in 30° flexion and further flexion was done as per the surgical need. The use of tourniquet was entirely surgeon dependent.

## 2.2 Approach

There were two approaches, the dual incision approach and a single incision approach.

## 2.3 Anterior Approach

The single incision approach utilized anterior medial or lateral parapatellar approach depending upon the surgeon's choice and the type of fracture. A single midline incision and extended medial or lateral parapatellar approach was used by Imam et al. for the fixation of the C3 type of distal femur fractures[3].


**Fig. 1. Anterior parapatellar approach**

## 2.4 Dual Incision Approach

A direct lateral approach (Fig 2) was made with the skin incision longitudinal and distally centered over the lateral epicondyle. The length of the incision was determined based upon the extent of the fracture.

For the medial approach (Fig 3) a straight medial skin incision was made over the adductor tubercle and extended proximally into the distal thigh.

Steinberg et al. utilized dual incision for the double plating approach in the fracture of the distal femur[9].

Intraoperative fluoroscopy (Fig 7) was checked to insure adequate reduction of the fracture fragments and congruency of the articular margin.

After the placement of the screws when the adequate reduction was achieved locking screws were inserted.

Finally, the medial plating (Fig 8) was done by the plane as described above.

Final reduction was achieved and confirmed under fluoroscopy (Fig 9).

## 2.5 Post Operative Care

All the patients were either given a posterior long leg slab or knee brace for at least two days for adequate soft tissue healing and to alleviate the pain. Early knee physiotherapy was initiated and full range of motion was tried to achieve as much as the patient could tolerate. Weight bearing was allowed according to the clinical and radiological findings on subsequent follow up visits. The patients were followed at 4 weeks interval for the first 3 months, at 6 weeks for the next three months and then at three months intervals till the final follow up. Radiographic healing was confirmed by the union of the three cortices of the bone on the antero-posterior (AP) and lateral radiographs. Clinical healing was confirmed by the absence of pain on weight bearing or application of stress over the injured site on examination and grading was done according to the Knee Society Score (Table 4). Rotation was checked by comparing with the opposite normal limb.

## 2.6 Choice of Implants

For the lateral condylar fragment, a distal femoral locking plate (DFLP) is used (Fig 10). These are anatomically contoured locking plates creating a fixed angle construct that improves fixation. There is multiple screw fixation in the femoral

condyle. Threaded holes in the plate head accepts 6.5mm of cancellous locking screws. Combi holes combine a Dynamic Compression unit (DCU) with a locking screw hole, which allows flexibility of axial compression and locking capability throughout the plate length. The plate shaft accepts 4.5mm simple cortical and 5.0 mm locking cortical screws.

**Fig. 2. Lateral incision**

**Fig. 3. Medial incision**

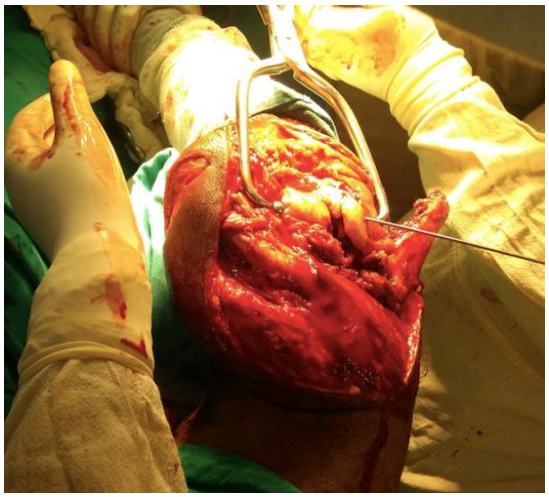

**Fig. 4. Use of pointed clamp**

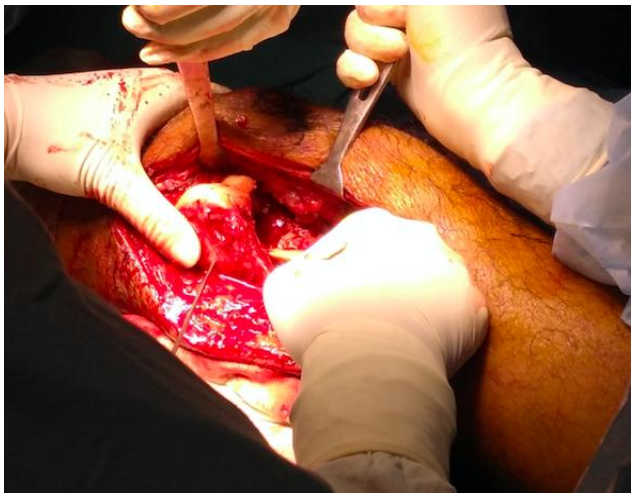

**Fig. 5. Use of K-wire**

**Fig. 6. Lateral plate application**

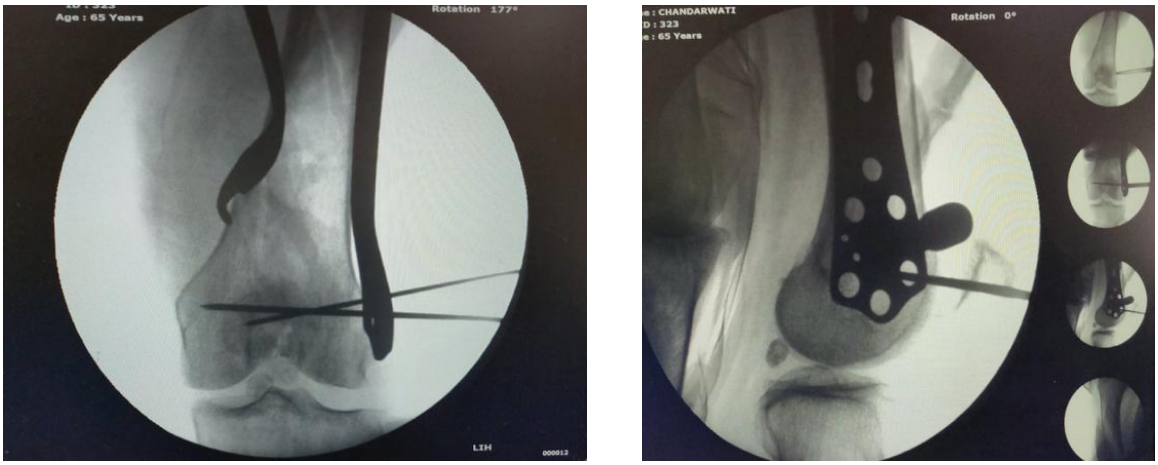


**Fig. 7. Intraoperative AP and Lateral fluoroscopy**

**Fig. 8. Medial plate application**

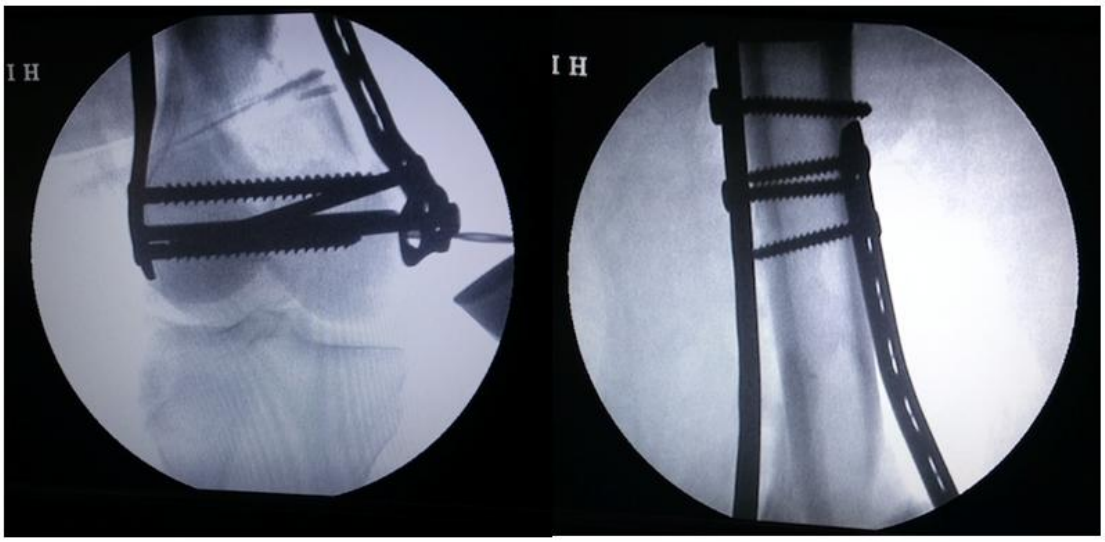


**Fig. 9. Intra-operative fluoroscopy**

**Fig. 10. DFLP**

**Fig. 11. T-plate**

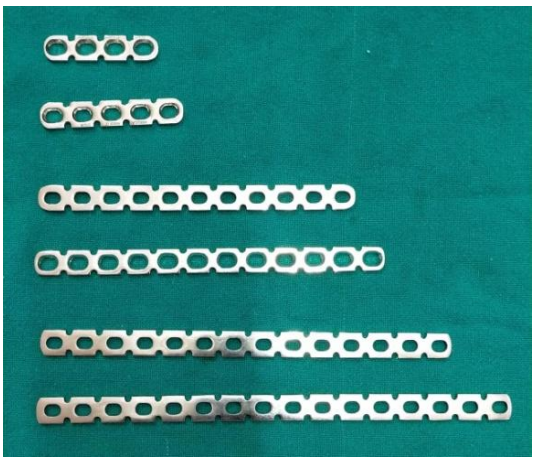

**Fig. 12. Recon plate**

For the medial buttressing either T-plate or recon plate was used. The plate was bended intraoperatively using a plate bender to prepare a contour best fitting the geometry of the fracture and also maintaining the joint congruency. Till now there is no consensus drawn as to which plate to be used for the medial condyle fragment nor are there any specially designed plates for the same. Imam et al.[3] used proximal tibial plate in ten cases and distal tibia plate in six cases in their study of double plating of intra-articular multi-fragmentary C-3 type of distal femoral fractures through the anterior approach.

## 3. RESULTS AND OBSERVATIONS

This was a study utilizing 32 patients (21 M and 11 F), with a mean age of 46 years ranging from 20 to 65. Some of the patients' particulars are summarized in Table 1.

Amongst the 32 patients; 9 were of type A3, 7 of C2 and 16 of C3 according to the OA classification. 21 were closed, 4 of Grade I and 7 of Grade II according to the GA classification. Most common mode of injury was RTA. 29 patients fell in this group. 1 sustained injury due to fall from height and 2 due to fall on ground. Talking about the surgical approaches; anterior midline approach was used in 19 patients and dual incision approach in the rest 13 patients.

We had a total of 11 open injury comprising (34.4%) of the total cases. 4 were of GA I and 7 were GA II. All the grade I and grade II open injuries were operated the same day under the intravenous antibiotic coverage. Amongst the open injuries there were none of grade III nor were any injuries with gross contamination. Dual plating was used in all these fractures from the very beginning. The risk of infection was evaluated by the presence of wound dehiscence

around the incision margin, any discharge from the wound, soaking of the dressings and fever. There was a total of 5 patients who had such episodes, 2 were of Grade I and the other 3 of Grade II open injuries. Fortunately, only one of our patients had deep infection. None of the closed fracture patients showed such episodes.

Mean duration between injury and fixation was 7 days ranging (1-15) days. Mean duration of surgery was 110 minutes ranging (90-150) mins. Mean amount of blood loss was 500ml ranging (350-800) ml.

The follow up time of our cohort ranged from 6 to 29 months with a mean of 18 months. Union was achieved in 29 patients, 2 patients required autologous bone grafting in later surgery and 1 had non-union due to deep infection. Mean duration of union was 6 months.

Range of motion exercises were started after 2 days post op. Our aim was to attain 90° of flexion by stitch removal averaging 14 days post op. After 14 days the wound was examined and when there were no chances of wound dehiscence further Range of Motion (ROM) exercises were started. 9 patients attained the ROM beyond 135°. Most of the patients numbering 22 fell in the ROM of (90-135°). 1 patient had a ROM less than 45° as he presented late to our side because he had head injury and couldn't strictly follow the commands. He subsequently developed stiff knee with just a jog of movement. There was no extension lag seen in our cohort. Mean ROM was 120 degrees.

**Table 1. (GA- Gustilo Anderson; R= right, L= left; RTA= road traffic accident, FFH= fall from height, FOG= fall on ground)**

| | OA Classification | | | GA Classification | | | Limb | | Mode of Injury | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A3 | C2 | C3 | closed | Gr I | Gr II | R | L | RTA | FFH | FOG |
| No of Patients | 9 | 7 | 16 | 21 | 4 | 7 | 18 | 14 | 29 | 1 | 2 |

**Table 2. Types of Approach and Implants**

| Approach | Number |
|---|---|
| Anterior midline | 19 |
| Dual incision | 13 |
| IMPLANT | |
| Lateral - DFLCP | 32 |
| Medial | |
| T-plate | 29 |
| Recon plate | 03 |

**Table 3. Intra-operative and follow up details**

| Variables | Studied cohort (n=32) |
|---|---|
| Operative time (min) | |
| Mean | 110 |
| Range | (90-150) |
| Blood loss | |
| Mean | 550ml |
| Range | 350-800 |
| Complications | |
| None | 26(81.25%) |
| Superficial infection | 3(9.3%) |
| Deep infection | 1(3.1%) |
| Stiff knee | 1(3.1%) |
| ITB syndrome | 1(3.1%) |
| Follow up (months) | |
| Mean | 18 |
| Range | 6-29 |

Functional assessment was done according to the knee society score (KSS). Score in the range of (80-100) was considered Excellent, in the range of (70-79) as Good, in the range of (60-69) as Fair and that below 60 as Poor.

**Table 4. Knee society score (KSS)**

| **PAIN** | |
|---|---|
| None | 50 |
| Mild or occasional | 45 |
| Stairs only | 40 |
| Walking and stairs | 30 |
| Moderate | |
| Occasional | 20 |
| Continual | 10 |
| Severe | 0 |
| Range of motion | |
| 5°=1 Point | 25 |
| STABILITY | |
| Antero-posterior | |
| < 5 mm | 10 |
| 5-10 mm | 5 |
| 10 mm | 0 |
| Medio-lateral | |
| < 5° | 15 |
| 6-9° | 10 |
| 10-14° | 5 |
| > 15° | 0 |
| Total positive points | [ +] |
| Deduction points | [-] |
| Flexion Contracture | |
| 5-10° | 2 |
| 11-15° | 5 |
| 16-20° | 10 |
| > 20° | 15 |
| Extension lag | |
| < 10° | 5 |
| 10-20° | 10 |
| >20° | 15 |
| Alignment | |
| 5-10° | 0 |
| 0-4° | 3 points each degree |
| 11-15° | 3 points each degree |
| Other | 20 |
| Total negative points | [ ] |
| Total knee score | [ ] |

7 patients showed excellent result (21.8%), 17 showed good result (53.2%), 5 showed fair (15.6%) and 3 (9.4%) showed poor result.

There were no varus or valgus deformity seen in our study. This evaluation was done using scanogram of the bilateral lower limbs and comparing the mechanical and anatomical axes of both the sides. Nor were there any hardware failure or intra-articular penetration. There were 4 superficial infections which were managed by simple iv antibiotics and dressings. There was 1 deep infection which was initially managed by debridement and iv antibiotics but later turned into nonunion. There was 1 Iliotibial Band Syndrome (ITBS).

### 3.1 Case

This figure is showing the x-rays and clinical pics of a male of age 20yrs who had a 33C2 type of fracture of the distal femur according to the OA classification. The patient was operated in the emergency on the very same day he sustained injury. Dual plating was done by the anterior incision approach. The patient achieved full ROM by 6 weeks post op and complete radiological union by 20 weeks. There was no shortening or any limp.

## 4. DISCUSSION

Fracture of the distal femur pose a considerable challenge for the orthopedic surgeon. Till date there hasn't been a single surgical technique or a single type of implant which could address all the needs. There are many factors which come into play while considering these types of fractures. These include patient's age, the bone quality, the extent of soft tissue injury, the amount of comminution, the type of instrument to be used and the most importantly the articular involvement [9].

Although nonoperative treatment was the treatment of choice prior to 1970, its use now is reserved for a few situations: reliable patients with minimally displaced fracture, in non-ambulatory patients (e.g., paraplegia), in patients with significant underlying medical diseases. Nonoperative treatment of a displaced distal femur fracture includes closed reduction with skeletal traction with or without subsequent cast bracing[10].

Early attempts at internal fixation of distal femur fractures were associated with a high incidence of malunion, nonunion, and infection. Because of these poor early operative results, numerous authors concluded that nonoperative methods were preferable. For example, Neer et al. reviewed a large series of supracondylar fractures and reported in 1967 good results in 84% of patients treated nonoperatively, but only 54% good results in surgically treated patients[10].


**Fig. 13. Pre-Operative**

**Fig. 14. Post-Operative**

**Fig. 15. 6 Weeks post OP**


**Fig. 16. 20 Weeks post OP**

**Fig. 17 and 18. Clinical Photographs**

Only one study, published by Butt et al. in 1996, has assessed nonoperative versus operative treatment for distal femur fractures. The results overwhelmingly favored operative treatment with a threefold decreased risk for complications of immobilization (DVT, UTI, pressure sores, and pneumonia) and a 33% risk reduction for poor results [10].

In the 1970s and early 1980s, distal femur fractures were most commonly treated with an anatomically contoured, but angularly unstable (non-locking) distal femur plate (e.g., condylar buttress plate). Relatively high complication rates were reported, which adversely affected clinical results, including infection, nonunion or delayed union, malunion (especially varus collapse), the need for bone graft, and knee stiffness owing to delayed mobility [11].

Later there were also advances in plate-screw design. Fixed angle implants such as the 95-degree angled blade plate (ABP) and dynamic condylar screw (DCS) provided drastically improved stability compared to prior implants. When these two methods were combined, they dramatically improved the rates of bone healing with fewer complications. However, insertion of these implants was technically demanding limiting their widespread use[12].

More recently, “locked plating” systems have been developed in which screws are inserted that lock into the plate, forming a fixed angle construct. Condylar fixation with locking screws is mechanically superior to earlier implants (e.g., blade plate or DCS) by spreading out fixation points among a number of screws. A variety of other plating systems have since been developed that offer additional advantages including better anatomic contouring, improved fixation in the condylar segment, and options for conventional screws, bi-cortical or uni-cortical solid locking screws, and cannulated nonlocking or locking screws. The mechanics of fracture healing using these implants are better but still incompletely understood and surgeons are investigating novel ideas for optimizing this mechanical environment by modulating the degree of stiffness and mobility in the fixation construct [12].

Most of the published studies on lateral locking plate have reported a union rate ranging from 81%-95%[13-17]. The complications related to implants including loosening, breakage and rotational malposition, were reported as being between 5% to 7% with a revision rate between 19% to 23%[16,17]. Some other potential problems were regarding the plate positioning, like the plate placed too ventral, too proximal or too short [24] which may weaken the mechanical stability leading to early implant loosening and failure.

Comparing the two approaches of dual plating intra-op, it was the anterior approach which had a better visualization of the fracture geometry, less tiring for fracture reduction, had less amount of blood loss. It allows better visualization of the anterior and lateral walls of the femur and prevents medial dissection. Additional two plates can be placed by a single incision in a 90° angle to each other. The concept is somewhat similar to the distal humerus plating.

It is essential to orient the plate properly to the joint on the anteroposterior projection. The plate sits at an inclined angle on the lateral femoral cortex matching the shape of the femur. If this is not recognised the distal screws will aim anteriorly and penetrate the patellofemoral joint. Proximally, it is essential that the plate sits along the mid-axis of the shaft and not too anterior or posterior, which is a common error in percutaneous plating. The number of screws and their configuration are controversial[3]. Distally we preferred to use as many locked screws as possible in our construct. Proximally, we preferred a near–far pattern of locked screws, with a total of at least five or six screws.

Double plating utilizing the anterior medial parapatellar approach delivers superb visualization and permits controlled access to the distal femur while minimizing inadvertent stripping of the medial side [3].

The only difficulty that we encountered was the decreased ROM at knee. These types of fractures are caused by high velocity trauma with resultant muscular and capsular injury causing extensive adhesions of the quadriceps mechanism[18-21]. These results are probably attributed to the high energy nature of these injuries and resultant soft tissue damage. The application of medial plate which necessitated additional dissection of soft tissues also contributed to the contactures at knee.

The double-plating technique may overcome the complications encountered in single lateral plating by its properties that provide increased stability by compensating for some of the intraoperative technical errors to permit complete healing [9].

**Table 5. Comparison with other studies**

| Study | Year | No of patients | Type (Fracture) | Approach | Implant | Union | Result |
|---|---|---|---|---|---|---|---|
| Sanders et al | 1991 | 9 | C2, C3 | Dual incision | Condylar buttress plate | 100% | 55.56% Good |
| Ziran et al | 2002 | 36 | C2, C3 | Anterior lateral parapatellar | Condylar/blade plate & Dynamic comp/Recon plate | 73% | _ |
| Ayman et al | 2012 | 12 | C3 | Modified Olerud Extensile | DFLP & Recon/Semi-tubular plate | 100% | 58.4% Excellent-Good |
| Steinberg et al | 2017 | 32 | A3, C1, C2, C3 | Dual incision | DFLP & T-plate/ Recon plate | 93.7% | - |
| Imam et al | 2017 | 17 | C3 | Ext Medial parapatellar | DFLP & T-plate | 93.8% | 68.8% Excellent-Good |
| Metwaly et al | 2018 | 23 | A3, C1, C2, C3 | Anterior midline | DFLP | 100% | - |
| My Study | 2021 | 32 | A3, C2, C3 | Anterior midline and dual incision | DFLP & Recon/T plate | 90.6% | 75% Excellent-Good |

Various studies have shown that dual plating of the distal femur has given promising results.

Sanders et al [22] studies the cases of nine patients who had a complex fracture of the distal femur and a deficient medial-cortical buttress. Stable fixation was nor achieved by the single lateral condylar buttress alone. Collapse of the distal fragment into varus angulation was noted intra-operatively. Additional stabilization with a medial plate and a bone graft from the iliac crest was applied in all nine patients. At an average duration of twenty-six months of follow-up all the fractures healed. Most of the patients had the arc of motion at knee from 90° to 100°.

Thirty-two patients (26 females and 6 males, mean age 76 years, range 44–101) were included in the study by Steinberg et al [9]. Eight of them had a periprosthetic stable implant fracture and two patients were treated for nonunion. All fractures, excluding one that needed bone grafting and one refracture, healed within 12 weeks. One patient needed bone grafting for delayed union and one patient needed fixation exchange due to femur re-fracture at the site of the most proximal screw. Two patients developed superficial wound infection and one patient required medial plate removal after union due to deep infection.

In a prospective study done by Imam et al [3] sixteen patients were reviewed with supracondylar femoral fracture type C3, according to Müller long-bone classification system and its revision OA/OTA classification. These were treated using dual plating through extended anterior approach and bone grafting. The mean time of complete radiological union in the studied population was 6.0 ± 3.5 months with a range of 3–14 months. They have not observed postoperative varus or valgus deformity in our cohort. The majority (68.75%) of the studied patients showed significant improvement in range of motion (90°–120°) during follow-up. Eleven out of sixteen patients (68.75%) had well-to-excellent functional outcome. Poor outcome was reported in only two patients (12.50%).

Ziran et al [23] gave a study about thirty-five patients with 36 displaced distal femoral fractures (16 AO-type C2 and 19 AO-type C3). They were treated with an anterior approach and double plating and followed for an average of 7 (3–44) months. They used a longitudinal anterior incision to minimize stripping of the medial femur side, and two plates were placed orthogonally oriented. They also used a lateral condylar or a buttress plate and an anterior reconstruction or dynamic compression plate and reported uneventful healing within 16 weeks in 24 out of 36 reported patients.

Khalil and Ayoub [24] reviewed about twelve patients with closed C3-type injuries. Mechanism of injury was road traffic accident (RTA) in nine patients and fall from height in the other three cases. Eight cases were operated during the first week and four cases during the second week after injury. Mean follow-up was 13.7 months (range 11–18 months). Mean radiological healing time was 18.3 weeks (range 12-28 weeks), and all cases had good radiological healing without recorded non-union or malunion. Clinically, two cases (16.7 %) had excellent results, five cases (41.7 %) had good results, three cases (25 %) had fair results, and two cases (16.7 %) had poor results. No cases developed skin necrosis, deep infection, bone collapse, or implant failure. However, two cases (16.7 %) had limited knee flexion to 90° and required subsequent quadricepsplasty.

In a biomechanical study on synthetic bone that was done by Prayson et al [25] they reported that supplementation of the medial column by medial plate must be considered to prevent varus collapse, especially in highly comminuted metaphyseal fractures with bone loss.

There were some hurdles in our surgical procedure. We found it difficult to reduce the comminuted intra-articular C3 types of fractures. We often found difficulty for the placement of medial plate in C3 types of fractures, so had to adjust the plate accordingly. The placement of screw for the medial Hoffa's along with the C3 fracture was a cumbersome task.

## 5. CONCLUSION

Dual plating is an efficient method for the stabilization of the distal femur fractures. The addition of a medial buttressing plate, besides providing with a rigid fixation also maintains the bone alignment and prevents any varus or valgus deformities. Especial emphasis should be given to active knee physiotherapy in post op. The patient should be switched to Continuous Passive Motion (CPM) machine as soon as it is realized that no further flexion is being carried out by the patient.

## CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the author(s).

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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