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ORIGINAL ARTICLE

Functional and Radiological Outcomes of Double Plating of Comminuted Distal Femur Fractures

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Background

For distal femur fractures, double fixation structures are employed to allow for partial weight-bearing and encourage an early and immediate range of motion, thereby reducing the failure rate. This study evaluated the clinical and imaging results of treating unsteady distal femur fractures in adults by double plating with a lateral locked plate and a medial buttress plate.

Patients and Methods

A total of 21 cases (aged 18 and older) with comminuted acute distal femur fractures (AO Classification: A3, C2, and C3) participated in this prospective study. Both closed and open distal femur fractures (Grade I) were included in the study. Through lateral and medial incisions, all participants had surgery on their distal femurs.

Results

The correlation between age and Time of union was moderately positive (r=0.607, P=0.004). On the other hand, there were modest negative relationships between Time to union and diabetes mellitus (r=-0.539, P=0.012) and cigarette smoking (r=-0.507, P=0.019). Age, smoking, diabetes mellitus, infection, time to union, and stiffness were inversely associated with the functional score. At 6 months and 12 months, the functional score significantly increased compared with the 3-month score (P<0.05), with an additional significant increase observed between the 12 month and 6 month scores.

Conclusions

The application of double plating for comminuted unstable distal femur fractures yielded encouraging outcomes characterized by accelerated healing, enhanced functional recovery, early rehabilitation, and reduced complications. Double plating has proven to be an effective treatment option, offering substantial advantages for patients suffering from comminuted unstable distal femur fractures.

Keywords

Double fixation, Dual plating, Outcomes, Radiological score, Unstable distal femur fractures.

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INTRODUCTION

Less than 0.5% of the total fractures and 3–6% of femoral fractures are caused by injuries to the distal femur. Elderly women in their late seventies and youthful men in their thirties had the highest frequency of these injuries. The male demographic typically presents with a history of high-velocity trauma, while females often sustain fractures from lower-energy incidents associated with osteoporosis [1].

Distal femur fractures are defined clinically as those within nine cm of the distal femoral joint surface [2]. Distal femur metaphysis in older people is situated between the arthritic knee joint and the cortical bone, making it a stress concentration site that predisposes individuals to low-energy osteoporotic fractures [3].

Maintaining or restoring appropriate alignment is essential for the effective care of distal femoral fractures to promote good function of the extremities. Coronal plane alignment has been identified as the most challenging aspect to control and is critical for achieving favorable outcomes. The development of posttraumatic arthritis has been noted in cases where fractures heal with a valgus angle exceeding 15⁰ or any degree of varus alignment at the knee [4]. Distal femur fractures are linked to greater mortality and concomitant diseases than proximal femur fractures. Weight-bearing limitations during surgery can worsen patients' quality of life, lengthen the healing period, and increase the risk of complications [5].

Surgical fixation has been shown to yield superior results compared with nonsurgical approaches, leading to enhanced alignment, union, knee mobility, and overall functional outcomes [6].

Double plating, which offers more rigid fixation, enhances stability for an adequate duration to facilitate healing in high-energy/open fractures, metaphyseal fragmentation, or distal femur fractures with notable osteoporotic conditions [7].

Moreover, by reducing the lever arm's influence on the femoral axis, double plating reduces the force delivered to the fracture site [8].

Apart from granting regulated entry to the distal femur and diminishing medial side stripping, the medial parapatellar route also ensures good visualization during double plate fixation. The anterior technique reduces the requirement for medial dissection by assisting in the reduction and positioning of the medial plate. Rigid stability can be improved by positioning the anterior and lateral plates at a 90° angle to one another [3].

The goal of this study was to evaluate the functional and radiological results of double plating for adults diagnosed with experienced comminuted unstable distal femur fractures.

PATIENTS AND METHODS

This prospective investigation included 21 patients over the age of 18, encompassing both sexes, who came with acute comminuted (articular and extraarticular) distal femur fractures [9]. The Tanta University Hospitals' Ethical Committee approved (Approval code: 35883/9/22), and the study was carried out between April 2022 and April 2023 in Tanta, Egypt. Written informed consent was acquired from every individual involved.

Among the excluded criteria were open fractures that exceeded Grade I, pathological fractures, fractures linked to neurological or vascular injury, and localized acute or chronic infections.

Fracture classification according to AO/OTA classification (Figure 1).

Intraoperative preparation

No tourniquet was utilized in any of the cases, nor was a distal femoral distractor employed. The distal femur was accessed through two distinct incisions: one lateral and one medial. Given the extensive comminution of the fractures, open reduction was performed in all instances. To expedite recovery in patients with severely comminuted distal femur fractures, Iliac Crest Bone Graft was applied (Autogenous Iliac crest bone grafting was done according to the size of the bone defect if the defect was <5cm, cancellous bone graft was taken if the bone defect was >5cm, a strut of corticocancellous iliac bone was taken) [10]. Drains were utilized in each case.

Lateral approach to distal femur

Starting at Gerdy's tubercle, an incision is created in the skin along the outside of the thigh. The incision is then bent inward so it can pass over the outside of the femoral condyle. The most proximal extent of the fracture is used to define the proximal beginning position of the skin incision. The articular surface was exposed by an extended lateral incision 1–2cm distally, and then an arthrotomy was done to expose the articular surface. Following the incision line on the skin, the iliotibial band is segmented. A forward slant of the fibers is observed toward Gerdy's tubercle. The iliotibial band was separated with a single precise incision to allow for a perfect closure. Just below the iliotibial band in the final 8–10cm of the femur are the muscle fibers of the vastus lateralis, which were less densely packed. The fascia around the muscle tore away, revealing the muscle fibers of the vastus lateralis from the lateral intermuscular septum. A sideways and backward strain was felt by the vastus lateralis muscle. A select few of the profunda femoris artery's perforations were ligated in order to control the bleeding. Limiting muscle removal to the lateral side of the distal femur and preserving as much of the periosteum around it as possible were both critical for the eventual healing of the fracture. The articular surface was exposed using joint capsule arthrotomy. An incision was created in the joint capsule distally to the lateral meniscus, over the lateral femoral condyle's anterior segment. A blunt, pointed, and angled retractor is employed to reveal the joint surface.

Distal femur medial approach

The adductor magnus tendon's route was followed by an incision being made on the skin. The location of the adductor tubercle was determined by drawing a line proximally on the adductor tendon. An incision was performed in a straight line on the tendon of the adductor magnus. The size of the incision was determined by the fracture pattern.

The anterior boundary of the Sartorius's muscle was identified to aid in dissection, and the knee was bent to allow for its drawing backward. This caused the adductor magnus tendon to be visible. The adductor tubercle and the adductor magnus tendon connect anteriorly. This method can also be utilized to gain access to the popliteal neurovascular bundle, which is situated below the femur if needed. To achieve this, a cut is performed right below the adductor magnus. Although adequate passage to the posterior joint during a capsulotomy may be problematic, an examination of the joint's surface can be performed if required. A unique medial method was used to locate the medial plate. To secure the medial plate in place, two cortical screws were employed approximately, while two cancellous screws were utilized distally.

In each case, layers of closure were applied to the wounds after meticulous hemostasis was achieved and drains were placed. The iliotibial band was able to seal watertight with absorbable sutures. Seal the skin and subcutaneous tissues as you would normally.

Fracture reduction was made by traction, and with the aid of reduction clamps and bone holders, anatomical distal femoral locked plates were used for fracture fixation. T-shaped locked plates and Narrow DCP were also used.

Postoperative care

Postoperative lateral and anterioposterior knee radiography were done. Early mobilization instructions were given to every patient, advising them to use them for safety. On the lateral and anteroposterior radiographs of the bone, the unification of the three bone cortices indicates radiographic healing.

In clinical fracture union, the most common clinical criteria were the absence of pain or tenderness during weight-bearing (49%), the absence of pain or tenderness on palpation or physical examination (39%), and the ability to bear weight (18%). Clinical healing occurs when the injured area stops hurting when tested under pressure or when the patient is carrying their weight [11].

Follow-up

For the 1st two months following fixation, there were planned outpatient follow-up visits each two weeks. At the twelve-month mark, Follow-up outpatient appointments were conducted for patients. A clinical assessment using Sander's System of Scoring. A radiological assessment using the Lane-Sandhu radiological grading system and radiography (anteroposterior and lateral pictures of the distal femur). Sander's Method of Scoring: Sanders's described methodology employed the functional evaluation score to classify the clinical and functional results [12].

Interpretation of Sander's scoring system

[Excellent: 36–40 points, good: 26–35 points, fair: 16–25 points, and poor: 0–15 points].

Lane-Sandhu radiographic scoring methodology: adding up the scores from the three dimensions: remodeling signs, the existence of the fracture line, and bone production at the fracture gap. Lane and Sandhu use a 0–12-point scale. Each dimension may provide 0,2, or 4 points. The AO-ASIF recommendations were followed for ununited or ambiguous long bone fractures, and the overall perception of healing was recorded [13].

Functional treatment: Early range of motion helps restore movement in the early postoperative phase. With stable fracture fixation, the surgeon and the physical therapy staff will design an individual program of progressive rehabilitation for each patient. The regimen suggested here is for guidance only and is not to be regarded as prescriptive. Knee mobilization may be started immediately postoperatively. Both active and passive motion of the knee and hip can be initiated immediately postoperatively. Emphasis should be placed on progressive quadriceps strengthening and straight leg raises. Static cycling without load and firm passive range of motion exercises of the knee allow the patient to regain optimal range of motion.

Weight-bearing Touch-down weight-bearing (10–15kg) may be performed immediately with crutches or a walker. This will be continued for 6–10 weeks postoperatively. This is mostly to protect the articular component of the injury rather than the shaft injury. Touch-down weight-bearing progresses to full weight-bearing gradually over a period of 2–3 weeks (beginning at 6–10 weeks postoperatively). Ideally, patients are fully weight-bearing, without devices (e.g. cane), by 12 weeks.

Follow-up Wound healing should be assessed for 2–3 weeks postoperatively. Subsequently, 6,12 week, 6, and 12 month follow-ups are usually made. Serial radiography allow the surgeon to assess the healing of the fracture (Figure 2).

Thrombo-embolic prophylaxis Thromboprophylaxis should be given according to local treatment guidelines [14].

Statistical analysis

IBM Inc.'s statistical analyses in Chicago, Illinois, USA, were conducted using SPSS v26. The ANOVA (F) test with a post hoc Tukey test was administered to examine statistical differences among the three groups regarding their quantitative variables. The variables were presented as means with corresponding standard deviations. The χ^2

test was utilized to evaluate the frequency distribution of the qualitative factors. The link between several various variables was ascertained using the Pearson correlation equation. A statistically significant result is defined as a *P* value lower than 0.05 in a two-tailed test.

RESULTS

According to AO Classification, this table included demographics, comorbidities, trauma type, fracture type, and fracture classification (Table 1). lists the study patients' demographic information, comorbidities, trauma mechanism, fracture type, and fracture classification.

Table 1: Demographics, comorbidities, trauma type, fracture type, and fracture classification of the studied patients:

	***N*=21**
Age (years)	39±13.27
Sex	
Male	12(57.14)
Female	9(42.86)
Weight (kg)	68.7±7.86
Height (m)	1.7±0.07
Residence	
Urban	8(38.1)
Rural	13(61.9)
BMI (kg/m²)	24.8±3.32
Smoking	
Smoker	7(33.33)
Nonsmoker	14(66.67)
DM	
Diabetic	3(14.29)
Nondiabetic	18(85.71)
HTN	
Hypertensive	4(19.05)
Nonhypertensive	17(80.95)
Trauma mechanism	
High energy trauma	18(85.71)
Low energy trauma	3(14.29)
Fracture type	
Open (grade I)	8(38.1)
Close	13(61.9)
Fracture classification	
A3	7(33.33)
C2	9(42.86)
C3	5(23.81)

Data are presented as mean±SD or frequency (%); BMI: Body Mass Index; DM: Diabetes Mellitus; HTN: Hypertension.

A mean of 157.80±12.84min was spent during the operation; 2.1±0.83 days were spent afterward, and 5.52±1.24 months were spent at the Time of the union. Knee stiffness affected four people. There were related fractures in three of these patients. One person had conservative treatment for a bilateral calcaneus fracture and a first-lumbar vertebral fracture. The open reduction and plating were implemented to address the ipsilateral tibia fracture in the 2[ed] instance. In the 3[ed] instance, the tibia was interlocked to correct ipsilateral fractures in both leg bones. The functional score significantly increased between 3 and 12 months, with the greatest increase occurring at the 12-month mark ($P<0.05$). The radiological score exhibited a significant increment between 12 and 6 months ($P<0.05$); it also reported a considerable improvement from 12 to 3 months and from 6 to 3 months (Table 2).

Table 2: Duration of operative, postoperative stay, time of union, issues, functional, radiological scores, and fracture classification of the studied patients:

	***N*=21**			
Operative Time (min)	157.80±12.84			
Postoperative stay (days)	2.1±0.83			
Time of union (months)	5.52±1.24			
Issues				
Delayed union	3(14.29)			
Infection	3(14.29)			
Knee stiffness	4(19.05)			
Functional, radiological scores and fracture classification				
	3m	**6m**	**12m**	***P***
Functional score	14.7±2.74	27.5±1.86	37.9±1.77	<0.001*
	P_1<0.001*, P_2<0.001*, P_3<0.001*			
Radiological score	4.7±1.06	7.4±1.25	10.1±0.94	<0.001*
	P_1<0.001*, P_2<0.001*, P_3<0.001*			
	A3 (*n*=7)	C2 (*n*=9)	C3 (*n*=5)	*P*
Radiological score	6.33±0.51	10±0.5	6.75±0.5	<0.001*
Functional score	13.33±1.75	28.33±5.50	14.25±1.26	<0.001*

Data are presented as mean±SD or frequency (%); *:Significant; *P:* value less than 0.05.

The groups that were infected and those that were not infected differed significantly in terms of stiffness, Time of union, functional score, and radiological score. Comparing the infection group to the non-infected group, the infection group's radiological and functional scores were noticeably worse. The infection group exhibited considerably greater stiffness and a longer time to union than the non-infected group. Multiple regression analysis revealed that age, diabetes mellitus (DM), union time, and delayed union were all significant predictors of forecasters. Other factors (hypertension, operating Time, fracture type) did not significantly predict complications in multiple regression analysis (Table 3).

While DM (r=-0.539, P=0.012) in addition to smoking (r=-0.507, P=0.019) showed a significantly unfavorable connection, age and length of marriage showed a moderately positive link (r=0.607, P=0.004). There was a relationship between the kind of infection and fracture and the union time. Age, smoking, DM, duration of union, infection, and stiffness all showed unfavorable correlations with functional scores. The radiological score was negatively correlated with stiffness, age, cigarette smoking, DM, Time of union, and infection (Table 4).

Table 3: The patients' complications studied:

	Infection (*n*=3)	**Noninfection (*n*=18)**	***P***
Functional score	13.33±1.52	38.33±2.08	<0.001*
Radiological score	7.6±1.50	10.28±0.91	<0.001*
Stiffness	3(100)	1(5)	0.003*
Time of union	7.33±0.57	4.93±0.89	<0.001*

Regression for prediction of complications

	Coefficient	**Std. Error**	***t***	***P***	**R partial**	**R semi partial**
DM	0.319	0.3939	0.0227	0.043*	0.006288	0.004171
HTN	−0.3508	0.546	−0.642	0.5317	−0.1754	0.1182
Operative Time	−0.00455	0.01369	−0.332	0.7451	−0.09171	0.06109
Time of union	0.1655	0.07653	2.163	0.0498*	0.5144	0.3979
Type of fracture	−0.04113	0.2873	−0.143	0.8884	−0.03967	0.02634
Age	−0.0094	0.003662	−2.566	0.0194*	−0.5175	0.5032
Delayed union	0.8706	0.1871	4.653	<0.001*	0.7389	0.7185

Data are presented as mean±SD or frequency (%); *:Significant; *P*: value less than 0.05; DM: Diabetes Mellitus; HTN: Hypertension.

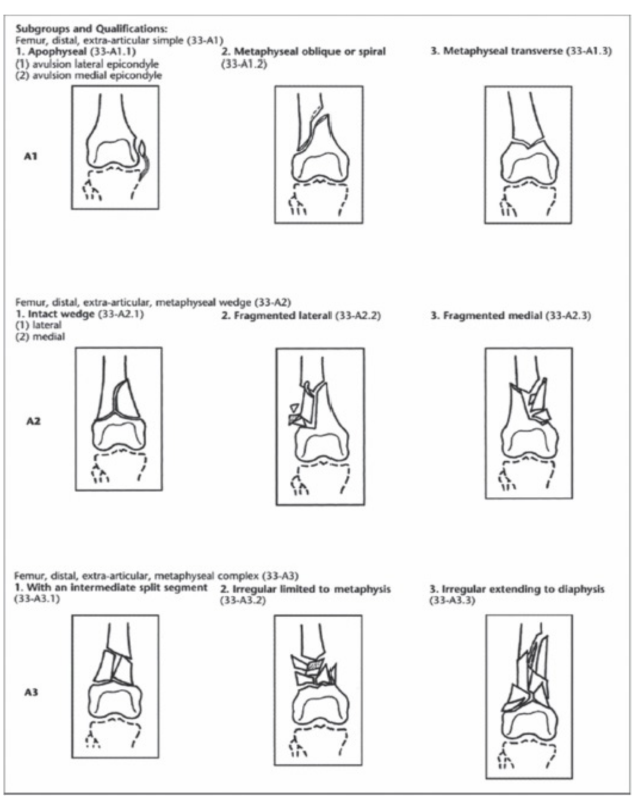

Figure 1: AO/OTA classification of distal femur type A fractures.

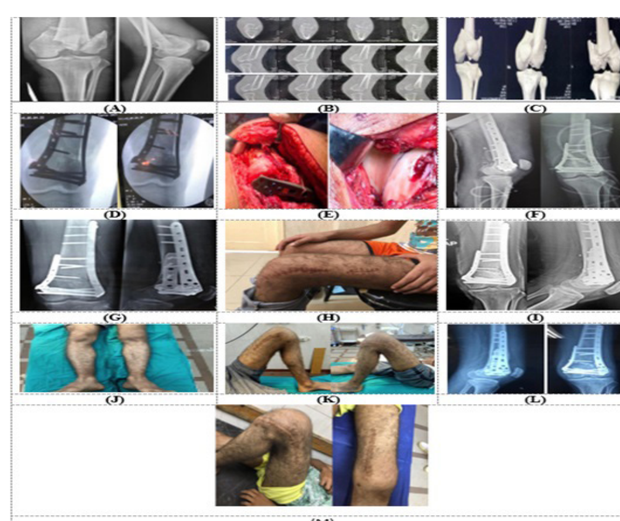

Figure 2: (A): Distal femur fracture with intercondylar extension seen on a knee joint radiography; (B,C): According to the AO/OTA classification, preoperative CT imaging of the knee joint reveals a distal femur fracture Class (C2.2); (D): Intraoperative imaging of the knee joint demonstrating double plating fixation and reduction of the distal femur fracture; (E): An intraoperative image demonstrating the reduction of a distal femur fracture and double plating fixation; (F): Right after surgery, a radiography Follow-up at 3 months for; (G,H): 6 months for; (I, J, K): and 12 months for; (L,M): Demonstrating fracture unions.

Table 4: Correlation between time of union, functional and radiological score, and different variables:

	Time of union	Functional score	Radiological score
Age			
r	0.607	−0.107	−0.310
P	0.004*	0.042*	0.035*
Sex			
r	0.260	−0.144	0.108
P	0.255	0.533	0.642
Smoking			
r	−0.507	−0.111	−0.351
P	0.019*	0.016*	<0.001*
DM			
r	−0.539	−0.638	−0.231
P	0.012*	<0.001*	<0.001*
HTN			
r	−0.047	−0.130	0.395
P	0.839	0.573	0.077
Mode of trauma			
r	0.356	−0.306	0.410
P	0.113	0.178	0.065
Type of fracture			
r	0.033	0.024	0.329
P	<0.001*	0.916	0.145
Time of union			
r	–	−0.014	−0.305
P	–	<0.001*	0.017*
Operative Time			
r	0.857	0.062	0.039
P	0.235	0.790	0.868
Infection			
r	0.739	−0.518	−0.631
P	<0.001*	0.016*	<0.001*
Stiffness			
r	–	−0.811	−0.811
P	–	<0.001*	<0.001*

r: Pearson coefficient; *: Significant; *P*: value less than 0.05; DM: Diabetes mellitus; HTN: Hypertension.

DISCUSSION

Problems arise during the reduction and fixation of distal femur fractures due to the bone's closeness to the knee joint and the influence of deforming forces. Preserving the vascularity and soft tissue vicinity of the fracture site is essential for achieving good clinical and functional outcomes, and it requires suitable and successful reduction procedures. The treatment for distal femur fractures now includes dual plating to overcome these difficulties. The stabilizing properties of dual plating allow for a more stiff and anatomically correct attachment [7].

Seven (33.33%) patients in this research had an A3 fracture classification, nine (42.86%) patients had a C2 classification, and five (23.81%) patients had a C3 classification.

According to research by Pai Manjeswar *et al*., [1], type C2 fractures constituted 40% of all instances, whereas type C3 accounted for 20%. While Rekha *et al.,* [15] reported that 46.7% of their cases were classified as type C., Steinberg *et al*., [8] showed that dual plating boosted the union rates in type C3 distal femur fractures.

13(61.9%) of the patients in this research had closed fractures, whereas eight (38.1%) of the patients had open fractures.

The majority of the fractures in the research conducted by Pai Manjeswar *et al*., [1] were closed fractures, comprising 88% of the cases. Conversely, only 12% of the fractures in this study were open.

Our findings showed that the union time was 5.52±1.24 months, the postoperative stay was 2.1±0.83 days, and the mean operating time was 157.80±12.84min. Knee stiffness affected four people. There were related fractures in three of these patients. One person had conservative treatment for a bilateral calcaneus fracture and a first-lumbar vertebral fracture. In the second instance, the fracture of the ipsilateral tibia was repaired using open reduction and plating. In the third instance, the tibia was interlocked to heal ipsilateral fractures in both leg bones. Imam *et al.,* [16] investigated the double plating technique for distal femoral fractures of the C3 type that are intraarticular and need anterior access. The findings revealed a mean time of union of 6±3.5 months and an average follow-up duration of 11.5 months, with a range spanning from 3 to 14 months. The examined cohort's mean radiographic union duration was 18 weeks, spanning a period of 14 to 24 weeks, according to Purushotham and Patil [17].

At 6 and 12 months, we observed significant enhancements in functional and radiological scores compared with 3 months, with additional enhancement at 12 months compared with 6 months. Regarding functional scores, radiological scores, stiffness, and Time to union, a substantial difference was found between the infection and non-infection groups. The infection group demonstrated significantly lower radiological and functional scores but had markedly higher stiffness and longer Time to union. According to Khalil Ael and Ayoub [18], superficial infection was recorded in two (16.7%) cases. Purushotham and Patil [17] showed that superficial infection delayed union occurred in one (6.7%) patient. Kandel *et al.,* [4] found that four (16.7%) had infection.

The research had certain limitations, one of which was the limited sample size. Only one facility was used for research. Only a brief period was allotted for patient follow-up. A larger multicenter study with a wider range of injuries is needed to generalize our findings.

CONCLUSION

The application of double plating for comminuted unstable distal femur fractures yielded encouraging outcomes characterized by accelerated healing, enhanced functional recovery, early rehabilitation, and a reduction in complications. Double plating has proven to be an effective treatment option, offering substantial advantages for patients suffering from comminuted unstable distal femur fractures.

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Authors' contribution: All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by M.E.M.A.K., M.A.A., and M.R.E. The first draft of the manuscript was written by M.E.M.A.K. and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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