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Evaluation of functional outcome of double locking plates for the treatment of Intraarticular distal femur fractures.

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Abstract:
Introduction:*Fractures of the distal femur are difficult orthopaedic injuries, frequently the consequence of high-velocity trauma and carrying a high morbidity rate.Traditional management approaches have evolved towards surgical intervention, specifically ORIF (open reduction and internal fixation), to address the complex nature of these fractures. While condylar buttress plates were once commonly utilized, modern fixed-angle implants, such as lateral locking plates, have demonstrated superior biomechanical properties. However, concerns persist regarding varus collapse and instability, particularly in cases with significant comminution.*

Methods and materials: *In this prospective study conducted between January 2021 and January 2022, we evaluated the efficacy of a novel double-plating technique in distal femur fracture management. Twenty-two patients meeting specific inclusion criteria underwent surgical treatment utilizing both lateral and medial fixation. Pre-operative evaluation, operative techniques, and post-operative management were standardized across all cases with a follow-up period of 1 year.*

Results: *Our results demonstrate promising outcomes with a 100% union rate and a mean healing time of 16-24 weeks. Functional findingshave been predominantly good to excellent, with a significant proportion of patients achieving a range of motion exceeding 90°. Notably, no varus deformities were observed postoperatively, highlighting the efficacy of the dual-plating technique in maintaining anatomical alignment and preventing complications.*

Conclusion: *Our research underscores the importance of individualized treatment strategies in the distal femur fractures management, with a focus on achieving anatomical reduction, stable fixation, and early mobilization. Further research with the larger cohorts as well as long-term follow-up is warranted to validate the efficacy and durability of the double-plating technique in optimizing patient outcomes and enhancing the quality of care for individuals with distal femur fractures.*

Keywords: *Distal femur fracture; Double plating; Intraarticular fractures, Supra-intercondylar femoral fractures; Lateral locking plate.*

Introduction:

Distal femur fractures occur within 15cm from the distal femur articular surface, constituting approximately 5-6% of all femoral fractures [1,2]. Typically associated with high-velocity trauma, these fractures often involve comminution, soft tissue injury, and extension into the articular surface [3]. The management approach for distal femoral fractures has evolved from nonoperative methods to surgical intervention, specifically ORIF, owing to

advancements in operative techniques and implants. Anatomical reconstruction of the articular surface, axial and rotational alignment restoration, early mobilization, stable fixation, and functional rehabilitation are the surgical treatment primary objectives.

Historically, condylar buttress plates have been commonly utilized in the distal femur fractures treatment. However, the frequent association of these fractures with open injuries and infection led to complications such as proximal implant failure, delayed fracture union, and malunion, particularly varus collapse. Compared to condylar buttress plates, contemporary fixed-angle implants, such as intramedullary retrograde nails, angle-blade plates, and dynamic condylar screws, have shown better biomechanical qualities in minimizing varus collapse. Consequently, lateral locking plates have become the preferred choice for internal fixation, replacing common blade plates in the distal femur fractures [4,5]. Retrograde nails have been developed recently to provide greater stability as well as improved biomechanical performance for the distal femur fractures with minimal condylar comminution. However, in cases where there is a shorter distal fragment as well as metaphyseal comminution with a defect in the medial cortex, varus collapse because of the rising bending tendency under vertical load remains a common concern with single lateral locking plate fixation [6-8]. This study has proposed a double-plating technique to address this problem, which is akin to the method utilized for 2-column fractures of the distal humerus, acetabulum, and tibial plateau [9-13]. This approach aims to provide additional support for stabilizing distal femur fractures, based on previous studies and literature documenting failed cases encountered with the single lateral plating.

Methods and materials:
A prospective research has been carried out at the “Department of Orthopaedics and Traumatology, Saveetha Medical College, Chennai, between January 2021 and January 2022. The study included 22 patients meeting inclusion criteria, those aged over 20 years of age with fractures less than 2 weeks old, simple or compound grade 1 fractures (according to Gustilo & Anderson classification), and Muller Type A2, A3, C2, or C3 distal femur fractures. Exclusion criteria comprise patients under 20 years of age, compound grade II & III fractures, Muller type A1, type B1, B2, B3 or type C1 distal femur fractures, those with distal neurovascular deficit, systemic situationslike malignancy, osteoarthritis, immunocompromised states”. Upon admission, patients underwent pre-operative evaluation, including a complete history and clinical examination revealing abnormal mobility as well as crepitus. Distal vascularity has been calculated through various means, and baseline investigations were conducted. Standard radiographs and CT scans with 3D reconstruction were performed. Primary immobilization of fractures was achieved with upper tibial pin traction, and every patient gave their informed consent.

Operative techniques: All procedures were performed in the operating theatres under the combined spinal along with epidural anaesthesia. Patients have been positioned supine with the affected knee flexed at 90° with the help ofa bolster under the knee. A longitudinal straight midline incision that extended from above the fracture laterally across patella was used to achieve lateral fixation (Swashbuckler approach). The incision was made all the way down to the quadriceps fascia, which was cut and separated from the vastus lateralis muscle laterally until it joined the iliotibial band. Laterally, the fascia and iliotibial band were retracted, and the dissection was carried out all the way to the linea aspera. Following the slicing of the lateral parapatellar retinaculum, which separated it from the vastus lateralis, a lateral parapatellar arthrotomy was performed in order to obtain access to the femoral condyles. The rebuilt condyles were then covered with a plate that was positioned submuscularly and fastened with locking screws.
Using a medial subvastus technique, medial fixation was carried out following lateral fixation. Following the adductor canal, an anteromedial incision was made from the anterior margin of the pes anserinus. This incision was made after the fascial envelope that encircled the vastus medialis was cut along the posterior border of the muscle. The adductor tubercle's muscle and the intermuscular septum's attachment to the intact proximal femur shaft were elevated via blunt dissection. It was decided to make a distal cut into the medial capsule that was two to three centimetres broad at the tendinous insertion of the vastus medialis. After a satisfactory reduction, the joint was exposed via a medial parapatellar arthrotomy. The traverse portion was positioned distally, and the medial plate was inserted and secured with screws. Wounds were thoroughly irrigated and closed in layers, and

postoperatively wound inspection and dressing were performed on postoperative day (POD) 2 and POD 5, with suture removal performed on POD 12.

Every day, new and advanced passive mobilization exercises were started, with a motion range starting at 30 degrees. After two weeks, non-weight bearing with a walker was initiated, and six weeks later, partial weight bearing with a walker. After at least 12 weeks following surgery and radiological confirmation of bony union, full weight bearing was permitted. Patients were instructed to follow up at four, eight, and three-month intervals after that, for a maximum of one year. A thorough clinical investigation has been carried out at every follow-up, during which patients' subjective symptoms, including pain, swelling, and restricted movement, were evaluated. Active flexion along with extension exercises without loading have been utilized in the physiotherapy of patients, and the American Knee Society Scoring System was used to perform a functional assessment. Version 23.0 of the IBM Statistical Package for Social Sciences (SPSS) has been utilized to carry out the statistical analysis of the data. NY / Armonk: IBM Corp. For continuous or quantitative data, the means and standard deviations (SD) were used to present the data. In the meantime, percentages and frequencies were used to represent categorical or qualitative data. For a p-value to be considered statistically significant, it should be lower than a value of 0.05.

Result:

Between January 2021 and January 2022, 22 patients with intra-articular distal femur fractures were included in our study and received dual-locking plate treatment. The age of patients ranged from 26 - 76y/o, with a mean age of 42. In Our study, 68% of the cases were (15) males and 32 % of the cases were (7) females (figure 1). Given that males are more likely than females to engage in outdoor activities and be more susceptible to trauma, this indicates a higher distal femur fracture incidence in patients who are male.In our study,the right lower limb is more commonly affected in 13 individuals. The average time taken for the surgery was 179 minutes differs from less than 130 to 220 mins per surgery. 13.6 % of cases belong to Muller type A2, 27.2% cases with type A3, 45.4% cases with type C2, and 13.6% cases with type C3 fractures were noted in this research (figure 2). Since the majority of cases are related to traffic accidents, associated injuries typically include lower limb injuries on the contralateral side. Numerous patients with polytrauma experienced head trauma, multiple rib fractures, haemothorax, and upper limb injuries. In our study, the mean time for fracture union was found to be 20 weeks, with 8 out of 22 cases healing both clinically and radiologically within this time frame. The average time for fracture union varied from 16 weeks to 24 weeks. There was a total of 22 patients in our study, and 15 of them had knee scores that were higher than 70. The remaining seven patients had outcomes that were either fair or poor. A knee score of seventy or higher is considered to be satisfactory. After a year, the average American Knee Society score ranges from 58 to 89, with a mean of 74.85. In 5 out of 22 cases, the overall results were excellent, and in 13 cases, they were good. In three cases, the result was fair, and in one case, it was poor (Figure 3, Table 1). In our study, 5 out of 22 cases experienced complications. Of those, 4 cases led to knee stiffness, with 2 patients experiencing severe knee stiffness (Table 2).Beyond CPM and physical therapy, they were unable to achieve knee flexion greater than 50 degrees. With CPM and physiotherapy, the remaining two patients were able to achieve reasonable flexion up to 70 degrees. 1 patient hada superficial skin infection, which was treated conservatively with culture-sensitive IV antibiotics and regular wound dressing. We did not lose any patients to follow-up.

DISCUSSION:

Treatment of Distal femoral fractures presents challenges, particularly regarding surgical approaches for supracondylar fractures of the femur. Conservative methods, regardless of age, can lead to complications such as knee stiffness, malunion, and non-union. Early surgical intervention can lead to simpler nursing care, shorter bedridden periods, and improved soft tissue management. A number of surgical techniques are used, such as DCS, condylar buttress plates, angled blade plates, locking compression plates, interlocking nails, and open reduction and internal fixation. Postoperative immobilization is required because of the disadvantages of conventional plates, which include screw pullouts and less rigid fixation. Locking plates, on the other hand, offer more stable fixation by reducing screw-plate toggle and motion at the bone-screw interface.

When dealing with severely comminuted fracture fragments or significant bone defects on the medial side, relying solely on lateral plate fixation may lead to instability at the fracture sites. This can result in knee varus

deformity, plate and screw breakage, and non-union. In instances where single lateral plating is utilized, the incidence of varus collapse along with the non-union tends to be elevated. However, in our study, incorporating medial plating alongside lateral plating has proven effective in mitigating these issues. We observed that the addition of medial plating has eradicated instances of malunion or varus deformity.

The combination of the nail-plate technique offers a stable and well-balanced fixation method, enabling immediate weight bearing as well as early mobilization. This approach is particularly beneficial for cases where intramedullary nails cannot be utilized, such as those "with intra-articular comminution or segmental bone loss affecting the far (medial) cortex. Additionally, the intra-osseous plating technique is advantageous for addressing severely comminuted intra-articular fractures (type C3) where even double plating" may not provide sufficient stability [14].

In the fixation of bicolumnar fractures of the distal femur with comminution, several prognostic factors influence outcomes, including age, treatment method, degree of intra-articular involvement, and joint mobilizationtiming. Early initiation of rehabilitation, physiotherapy, and adherence to an aggressive post-operative protocol are essential for achieving optimal functional outcomes in these patients.

In 2017, Steinberg and colleagues conducted a study to examine the results of thirty-two patients who underwent dual plating for distal femoral fractures. With the exception of two cases that required bone grafting and one that experienced refracture, every fracture healed in less than a year. For delayed union, one patient had bone grafting; another needed fixation exchange because their femur had refractured at the location of the most proximal screw. Additionally, two patients developed superficial wound infections, and 1 patient underwent elimination of the medial plate post-union due to deep infection [15].

Ziran et al. treated 19 patients with distal femoral fractures of displaced AO-type C3 using dual plating and an anterior approach. With the exception of three patients, they were able to achieve near-anatomic reductions, and they came to the conclusion that dual plating using a single anterior approach provides excellent exposure with little medial dissection [16].

Similarly, Zhang et al. examined the practicability and clinical effectiveness of double plating fixation for type C3 distal femoral fractures by utilizing an anterior/middle method. They involved 12 cases, predominantly males injured in motor vehicle accidents or falls from heights. After a period of skin traction, surgery was performed using double plating fixation and bone grafting. The majority of cases resulted in excellent or good outcomes [17].

In a 2018 prospective study, Imam et al. investigated 16 patients with Muller "type C3 distal femoral fractures treated with dual plating. After evaluating the clinical, radiological, and complication outcomes, they observed a high proportion of good-excellent functional outcomes, with 68.75percent of patients with motion range" (90°–120°) at follow-up and a mean of 6.0±3.5 months for radiological union, with no postoperative varus as well as valgus deformity [18].

In our research, which aligns with these findings, we observed a 100% union rate with a mean time for healing of 16-24 weeks. Functional outcomes were excellent in 82% of patients, with 70% achieving a range of motion exceeding 90°. No varus deformities were noted postoperatively, and the majority of patients demonstrated significant improvement in range of motion (90°–120°) during follow-up.

Conclusion:

In conclusion, our study on distal femur fracture management utilizing a double-plating approach has demonstrated promising results in terms of fracture healing, functional outcomes, and complication rates. The utilization of dual fixation, comprising both lateral and medial plates, addresses the challenges associated with severely comminuted fractures and significant bone defects on the medial side, thereby providing enhanced stability and reducing the risk of varus deformity or malunion.

Declarations:
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Conflicts of Interest: None declared

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Figure 1: Sex Incidence

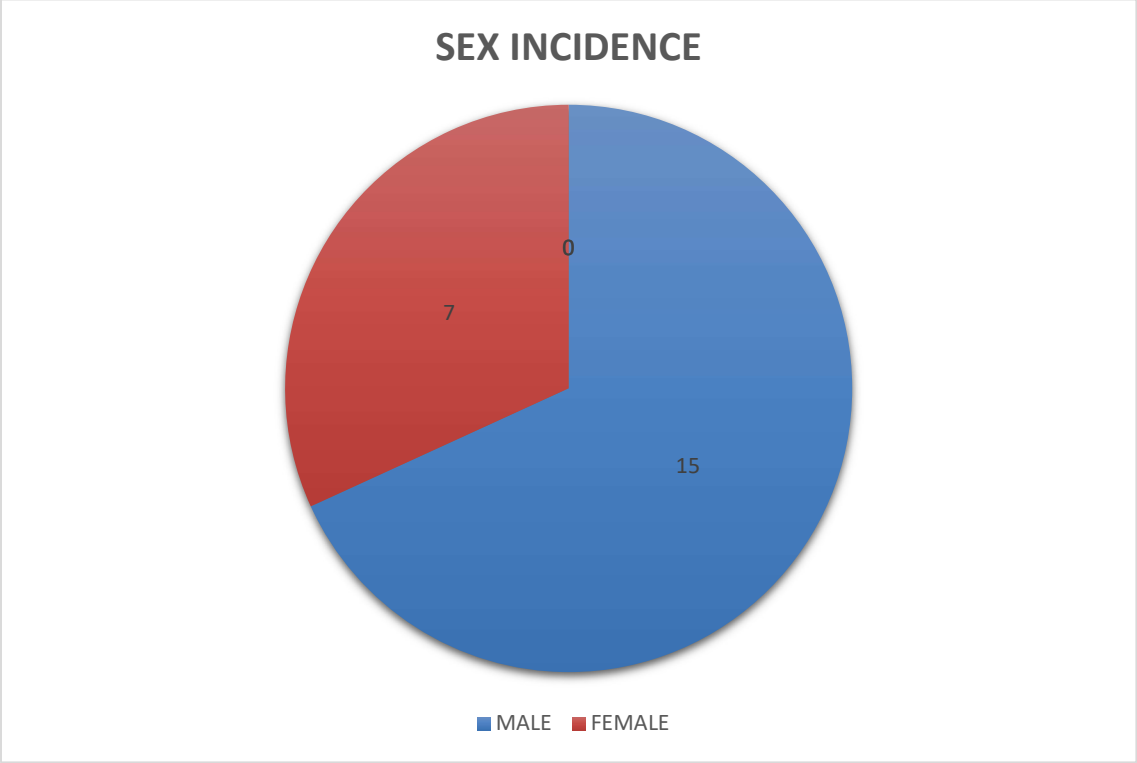

Figure 2: Fracture distribution according to Muller Type:

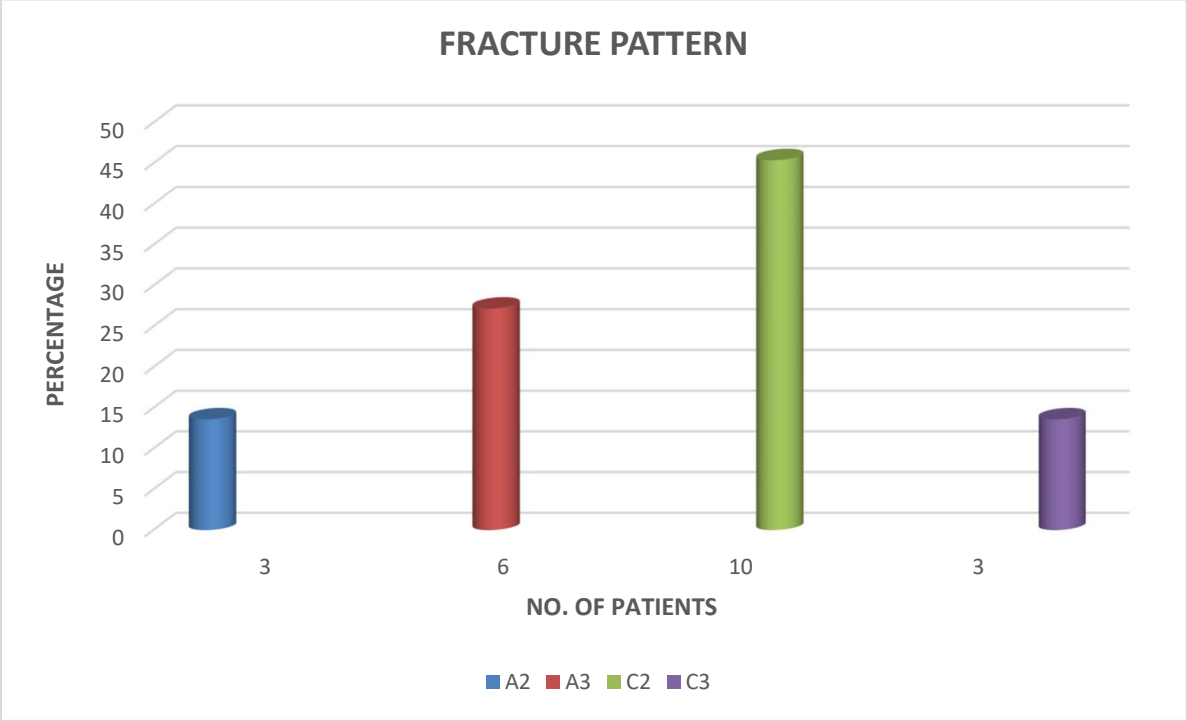

Figure 3: Outcomes of the study

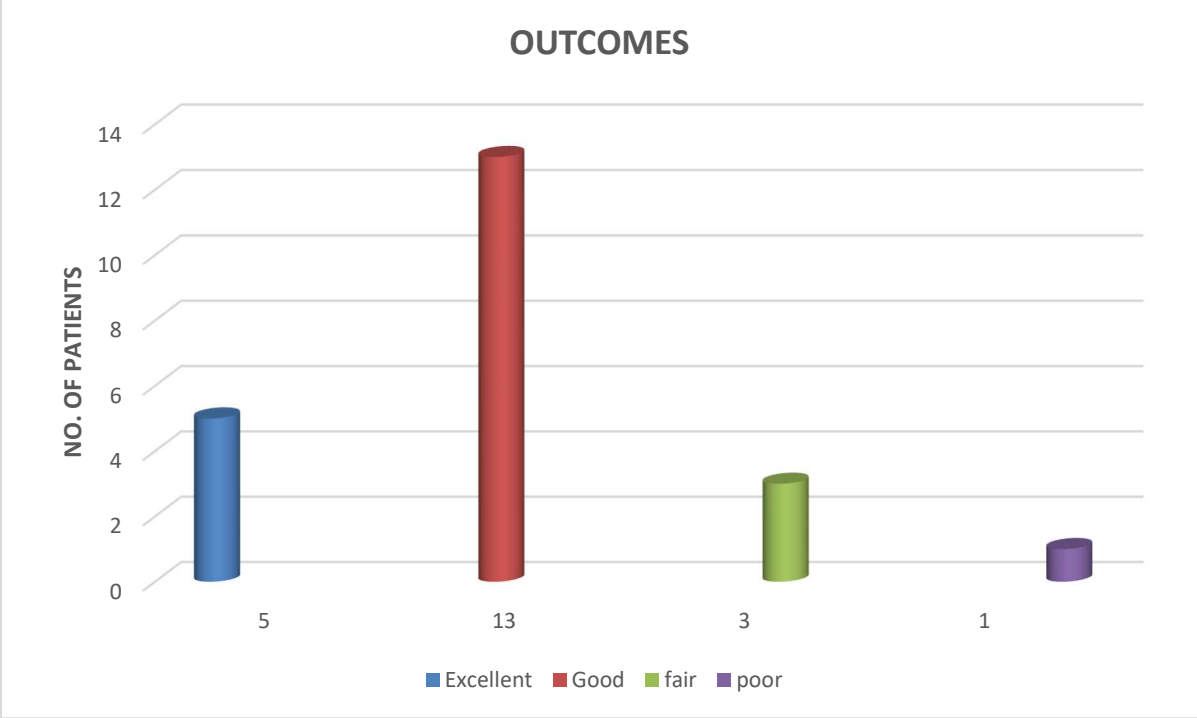

Table 1: Outcomes of the study

Score result	No. of patients	Percentage
Excellent	5	23%
Good	13	59%
Fair	3	14%
Poor	1	4%
Total	22	100%

Table 2: Master chart showing patient demographic and details:

S. No	Age	Sex	Side involved	Fracture Type	Associated injury	Operating time	Range of motion	Fracture union in weeks	American knee society score at 1 year	Outcomes	Complications
1	33	M	R	A3	-	150	0 to 50	22	73	Good	Knee stiffness
2	76	F	L	C2	Right Shaft of tibia fracture	165	0 to 100	20	75	Good	-
3	45	M	L	C2	-	130	0 to 90	18	76	Good	-
4	54	F	L	A3	-	190	0 to 90		79	Good	-
5	32	M	R	C2	Left BB leg fracture	175	0 to 100	18	85	Excellent	-
6	56	M	R	C2	-	185	0 to 90	24	58	Poor	-
7	34	F	L	C3	-	145	0 to 70	20	75	Good	-
8	53	M	R	A3	Multiple rib fractures	170	0 to 50	23	61	Fair	Knee stiffness
9	38	M	L	C3	-	220	0 to 80	19	88	Excellent	-
10	26	M	R	A3	-	145	0 to 90	16		Good	-
11	37	F	R	C2	-	210	0 to 90	18	71	Good	-
12	34	M	R	A2	-	190	0 to 100	20		Good	-
13	57	F	R	C2	Head injury	185	0 to 100	22	66	Fair	Superficial skin infection
14	28	M	L	C2		160	0 to 90	17	83	Excellent	-
15	34	M	R	C3	-	220	0 to 70	24	72	Good	Knee stiffness
16	39	M	R	A3	-	135	0 to 110	20	81	Excellent	-
17	43	M	L	A2	Right shaft of humerus fracture	185	0 to 100	20	77	Good	-
18	57	F	R	C2	-	220	0 to 90	24	64	Fair	-
19	33	M	L	A2	-	185	0 to 90	18	78	Good	-
20	29	F	R	C2	-	210	0 to 80	18	89	Excellent	-
21	45	M	R	A3	-	195	0 to 70	22	70	Good	Knee stiffness
22	43	M	L	C2	-	170	0 to 110	20	76	Good	-