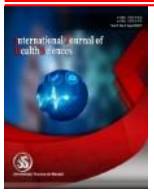


International Journal of Health Sciences

Available online at www.sciencescholar.us
Vol. 9 No. 3, December 2025, pages: 928-938
E-ISSN: 2550-696X
https://doi.org/10.53730/ijhs.v9n3.15830

Study on Functional Outcomes of Dual Plating in Comminuted Distal Femur Fractures

Muni Sankar Reddy M [a], **Jishnu J** [b], **Avinash Bajjuri** [c], **Venugopal S M** [d]

Manuscript submitted: 27 September 2025, Manuscript revised: 18 November 2025, Accepted for publication: 04 December 2025

Corresponding Author [d]

Keywords

AO/OTA 33-C2/33-C3;
Locking plate fixation;
Comminuted fracture;
Distal femur fracture;
Dual plating;
Early mobilization;
Functional outcome;
Medial column support;
Neer's knee score;
Radiological union;

Abstract

Background: Comminuted intra-articular distal femur fractures (AO/OTA 33-C2/C3) are technically demanding injuries associated with high rates of mechanical complications when treated with single lateral locked plates, particularly in the presence of medial column deficiency. Dual plating (lateral + medial locking plates) has been proposed to improve construct stability and facilitate early rehabilitation. This study evaluates radiological and functional outcomes of dual-plate fixation in a tertiary care setting. **Methods:** A prospective observational study was performed at BIRRD Hospital, Tirupati, from January 2022 to November 2024. Thirty-five consecutive adult patients (≥18 years) with AO/OTA 33-C2 or 33-C3 distal femur fractures treated with dual plating were included and followed for a minimum of 12 months. Demographic data, mechanism of injury, fracture type, time to radiological union, Neer's knee score, range of motion, time to weight bearing, and complications were recorded. Continuous variables are reported as mean ± SD; categorical data as counts and percentages. **Results:** Mean age was 42.6 ± 12.8 years (range 22–71); 24 patients (68.6%) were male. The mechanism of injury was predominantly road traffic accidents (74.3%). Fracture distribution was 33-C2 in 15 (42.9%) and 33-C3 in 20 (57.1%). Mean time to union was 16.8 ± 3.4 weeks; 91.4% (32/35) united without additional surgery. Functional outcomes at one year showed 16 (45.7%) excellent and 13 (37.1%) good results by Neer's score (combined excellent–good 82.8%). Mean knee flexion at final follow-up was 112° ± 15°; 82.9% achieved ≥90° flexion. Complications were few: delayed union in 3 (8.6%), superficial infection in 1 (2.9%), knee stiffness in 2 (5.7%), and implant failure in 1 (2.9%); there were no non-unions. Mean time to partial and full weight bearing was 6.5 and 14.2 weeks, respectively. **Conclusion:** In this series of comminuted distal femur fractures, dual plating achieved high union rates, favourable functional outcomes (excellent–good in 82.8%), satisfactory knee range of motion, and a low incidence of major complications. Dual plating is a reliable fixation strategy for unstable AO/OTA 33-C2/C3 fractures, allowing early mobilisation and predictable healing in a high-energy trauma setting. Further comparative studies with larger cohorts are warranted.

[a] Balaji Institute of Research and Rehabilitation for the Disabled (BIRRD) Trust Hospital, TTD, Tirupati, Andhra Pradesh, India
[b] Balaji Institute of Research and Rehabilitation for the Disabled (BIRRD) Trust Hospital, TTD, Tirupati, Andhra Pradesh, India
[c] Balaji Institute of Research and Rehabilitation for the Disabled (BIRRD) Trust Hospital, TTD, Tirupati, Andhra Pradesh, India
[d] Balaji Institute of Research and Rehabilitation for the Disabled (BIRRD) Trust Hospital, TTD, Tirupati, Andhra Pradesh, India

Contents

1 Introduction

Distal femur fractures represent complex injuries that pose significant challenges to orthopaedic surgeons due to their anatomical proximity to the knee joint, comminuted fracture patterns, compromised bone stock, and the need to restore limb alignment, articular congruity, and early functional recovery. These fractures account for approximately 4–6% of all femur fractures and demonstrate a bimodal distribution, affecting elderly osteoporotic women following low-energy trauma and young males involved in high-energy mechanisms such as road traffic accidents and falls from height. The complexity increases considerably in comminuted intra-articular fractures (AO/OTA type 33-C), where instability, metaphyseal bone loss, and soft tissue compromise frequently coexist (Gwathmey et al., 2010; Martinet et al., 2000).

Standard management of distal femur fractures has evolved from conservative treatment and fixed-angle blade plates to modern locking plate constructs and retrograde intramedullary nailing. Despite advancements, high rates of delayed union, malunion, implant failure, and nonunion have been reported with single lateral locked plating, particularly in highly comminuted and osteoporotic fractures. Ricci et al. (2014), highlighted that failure of lateral locked plate constructs is often associated with insufficient medial support, fracture comminution, and poor bone quality. This has driven the search for more biomechanically stable constructs capable of withstanding physiological loads and promoting fracture healing.

Dual plating, involving the application of both lateral and medial plates, has re-emerged as a viable solution for comminuted distal femur fractures. Historically described by Sanders et al. (1991), double plating provides enhanced construct stability by neutralizing varus collapse forces and restoring medial column integrity. Recent biomechanical and clinical studies have reinforced the superiority of dual plating over single lateral constructs, particularly in multifragmentary fractures and those with medial voids (Fontenot et al., 2019; Park et al., 2019; Zhang et al., 2018).

Biomechanically, dual plating offers increased axial stiffness, torsional resistance, and load-sharing capacity. Zhang et al. (2018), demonstrated superior fixation stability in AO type 33-C2 and C3 fractures with double plating when compared to single plate constructs. Similarly, Bologna et al. (2020), reported improved union rates and reduced mechanical failure in dual plating groups. These findings support the mechanical rationale for augmenting lateral locked plates with medial fixation, especially in comminuted configurations.

Concerns regarding soft tissue damage, vascular compromise, and increased surgical morbidity with dual plating have been addressed through minimally invasive techniques. Beeres et al. (2020) and Jiamton Apivatthakakul (2015), demonstrated the feasibility and safety of minimally invasive medial plate insertion, preserving periosteal blood supply while achieving stable fixation. Furthermore, Rollick et al. (2020) found no significant compromise in distal femoral vascularity when dual plating was performed with careful surgical technique.

Functionally, achieving a stable fixation that allows early mobilization directly influences long-term knee function. Restoration of alignment, articular congruity, and stable fixation are essential for knee range of motion, pain relief, and return to pre-injury activity levels. Clinical studies have increasingly reported favorable outcomes with dual plating in terms of knee scores, time to union, and complication rates (Bologna et al., 2020; Ebraheim et al., 2016; Sain et al., 2019).

The present study evaluates the functional outcomes of dual plating in comminuted distal femur fractures over three years with a minimum of one-year follow-up. The study aims to contribute to existing evidence by correlating radiological union and clinical function in an Indian tertiary care setting, where high-energy trauma remains a leading cause of such injuries.

Aims and Objectives

Primary Aim
To assess the functional outcomes of dual plating in comminuted distal femur fractures at one-year follow-up.

Objectives
1) To evaluate radiological union rates following dual plating.
2) To assess functional outcomes using standardized knee scoring systems.
3) To analyze complications such as nonunion, malunion, implant failure, and infection.
4) To correlate fracture type and demographic variables with functional outcome.
5) To determine the time to union and time to full weight-bearing.

2 Materials and Methods

Study Design
A prospective observational study was conducted at BIRRD Hospital, Tirupathi, from January 2022 to November 2024, including 35 patients with comminuted distal femur fractures treated with dual plating.

Inclusion Criteria
- Age ≥18 years
- AO/OTA type 33-C2 and 33-C3 distal femur fractures
- Closed or Gustilo-Anderson type I & II open fractures
- Patients undergoing dual plating fixation

Exclusion Criteria
- Pathological fractures
- Periprosthetic fractures
- Polytrauma patients with head injury affecting rehabilitation
- Patients lost to follow-up

Surgical Technique
All patients underwent dual plating using a lateral distal femur locking plate combined with a medial locking plate. A lateral approach with a minimally invasive medial approach was utilized depending on fracture morphology and medial comminution. Restoration of limb alignment and articular congruity was ensured under fluoroscopic guidance.

Postoperative Protocol
- Knee mobilization initiated within 48–72 hours
- Partial weight-bearing commenced at 6–8 weeks
- Full weight-bearing allowed upon radiological union

Data Collection

Clinical and radiological assessments were done at 6 weeks, 3 months, 6 months, and 12 months. Functional outcomes were assessed using Neer's Knee Score and range of motion measurements, and union time

Figure 1. AO/OTA 33-C3 (intra-articular, multi-fragmentary

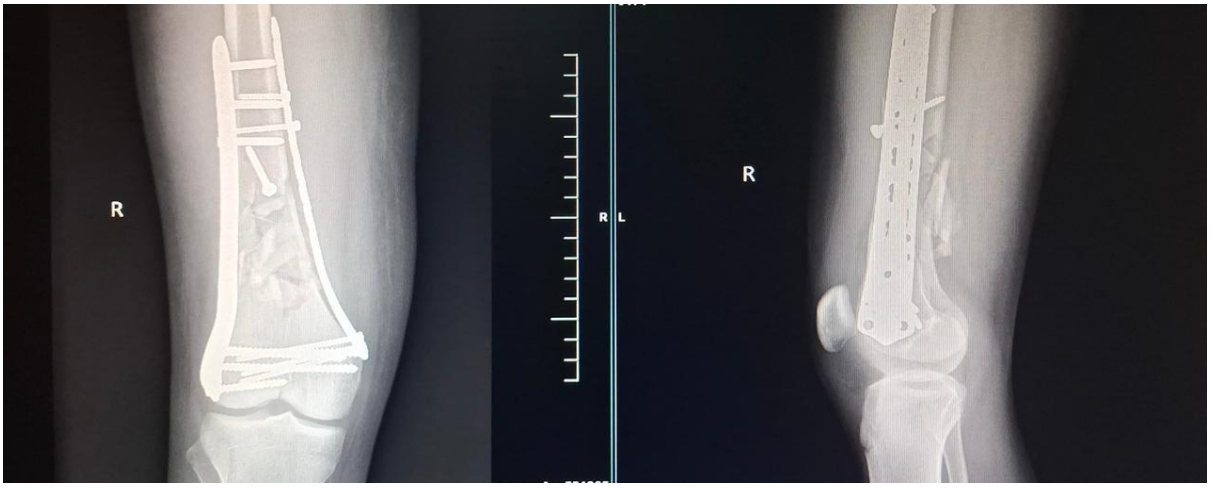


Figure 2. X-ray of the immediate postoperative fixation of the fracture with medial and lateral plates

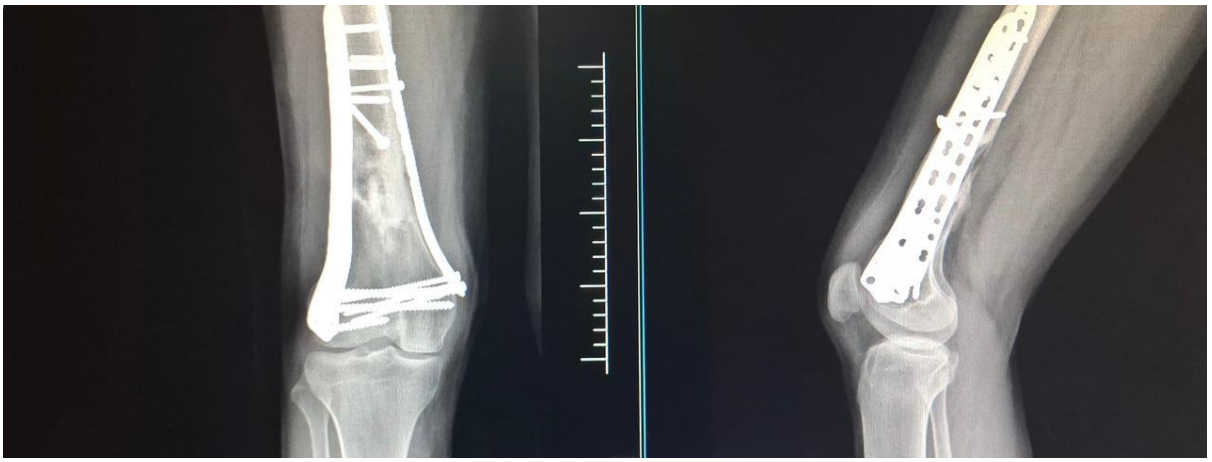


Figure 3. 5 months follow-up rays showing union

Statistical Analysis
Data was analyzed using descriptive statistics. Continuous variables were expressed as mean ± SD, and categorical data as percentages. Correlation between fracture type and functional outcome was analysed using chi-square and Student t-test, with p-values <0.05 considered statistically significant.

3 Results and Discussions

3.1 Results

A total of 35 patients with comminuted distal femur fractures treated with dual plating were evaluated with a minimum follow-up of 12 months. The results are presented below in tabular format with interpretation.

Table 1
Demographic Profile of Patients (n = 35)

Variable	Number	Percentage
Age (years)	Mean = 42.6 ± 12.8	Range 22–71
Male	24	68.6%
Female	11	31.4%
M: F	2.2: 1	–

The study population was predominantly male, representing 68.6% of cases. This reflects the higher incidence of high-energy trauma among males in the economically productive age group. The age distribution demonstrates involvement of both young trauma victims and elderly patients.

Table 2
Mode of Injury

Mechanism	Number	Percentage
Road Traffic Accident	26	74.3%
Fall from Height	6	17.1%
Domestic Fall	3	8.6%

Road traffic accidents constituted the primary cause of injury (74.3%), indicating severe trauma leading to complex comminution, justifying the use of a mechanically stronger construct such as dual plating.

Table 3
Fracture Classification (AO/OTA)

Fracture Type	Number	Percentage
33-C2	15	42.9%
33-C3	20	57.1%

More than half of the fractures were type 33-C3, indicating severe comminution and articular involvement. These unstable patterns required enhanced fixation stability, effectively addressed by dual plating.

Table 4
Time to the Radiological Union

Time to Union	Number	Percentage
< 14 weeks	8	22.9%
14–18 weeks	21	60.0%
> 18 weeks	6	17.1%

Mean time to union: **16.8 ± 3.4 weeks**

The majority of patients achieved union between 14–18 weeks, indicating efficient healing supported by stable fixation. Delayed union occurred in a minority but resolved with conservative management.

Table 5
Functional Outcome (Neer's Knee Score)

Outcome	Score Range	Number	Percentage
Excellent	> 85	16	45.7%
Good	70–85	13	37.1%
Fair	55–69	4	11.4%
Poor	< 55	2	5.7%

Excellent to good outcomes were noted in 82.8% of patients, indicating highly satisfactory restoration of knee function following dual plating.

Table 6
Range of Motion at Final Follow-up

Knee Flexion	Number	Percentage
>120°	12	34.3%
90–120°	17	48.6%
<90°	6	17.1%

Average knee flexion: **112° ± 15°**

Most patients achieved functional knee flexion above 90°, enabling effective performance of routine daily activities. Reduced motion was seen in patients with delayed rehabilitation.

Table 7
Complications

Complication	Number	Percentage
Delayed Union	3	8.6%
Superficial Infection	1	2.9%
Knee Stiffness	2	5.7%
Implant Failure	1	2.9%
Nonunion	0	0%

The overall complication rate remained low. No cases of nonunion were observed. Minimal implant failure and infection indicate good surgical technique and stable fixation.

Table 8
Weight-Bearing Status

Weight Bearing	Mean Time
Partial Weight Bearing	6.5 weeks
Full Weight Bearing	14.2 weeks

Early progression to weight-bearing was achieved due to the stability of the dual plate construct, contributing to better rehabilitation and reduced joint stiffness.

Table 9
Overall Results Summary

Parameter	Outcome
Union Rate	91.4%(rest delayed)
Mean Time to Union	16.8 weeks
Excellent–Good Outcomes	82.8%
Average Knee Flexion	112°
Overall Complication Rate	20%

Overall
Dual plating demonstrated excellent radiological and functional outcomes with high union rates, early mobilization, and minimal complications in comminuted distal femur fractures, affirming its role as a reliable fixation method for complex injuries.

3.2 Discussion

The management of comminuted distal femur fractures remains a significant challenge in orthopaedic trauma due to their inherent instability, metaphyseal comminution, intra-articular involvement, and frequent association with high-energy trauma. Traditional fixation methods using single lateral locking plates have been widely adopted; however, multiple studies have reported unacceptable rates of varus collapse, delayed union, nonunion, and implant failure, especially in fractures with medial column deficiency and osteoporotic bone. This has led to a renewed interest in dual plating constructs as a means to enhance mechanical stability and improve functional outcomes.

In the present study, dual plating in 35 cases of comminuted distal femur fractures demonstrated a union rate of 91.4% with a mean time to union of 16.8 weeks and excellent-to-good functional outcomes in 82.8% of patients. These results closely correlate with the findings of Steinberg et al., who reported improved union and better functional recovery with dual plating compared to isolated lateral plating, especially in comminuted fractures (Steinberg et al., 2017). Similarly, Bologna et al. (2020), found significantly higher union rates and fewer mechanical failures in patients treated with dual plating constructs.

The biomechanical justification for dual plating is well documented. Fontenot et al. demonstrated that medial supplementation significantly increases construct stiffness and reduces micromotion at the fracture site, which is crucial in comminuted and osteoporotic bone (Fontenot et al., 2019). Park et al. further showed that lateral locked plating alone often fails to counteract varus deforming forces, particularly when medial cortical contact is lost, making medial plate augmentation essential (Park et al., 2019). Zhang et al. (2018), confirmed that dual plating provides superior axial and torsional stability in AO 33-C2 fractures when compared to single lateral plate constructs.

In the current study, the majority of fractures were AO type 33-C3 (57.1%), representing highly unstable and complex patterns. The favorable outcomes observed reinforce the clinical relevance of applying dual plates in such fracture patterns. Sanders et al. (1991), were among the earliest to advocate dual plating for comminuted distal femur fractures, demonstrating improved stability and alignment maintenance. Recent clinical studies have continued to support these findings, especially in fractures with medial voids or metaphyseal bone loss (Steinberg et al., 2017; Bai et al., 2018).

Functional outcome is a critical parameter in evaluating the success of any fixation method. In this study, the average knee flexion achieved was 112°, and more than 80% of patients attained excellent or good Neer's knee scores. Metwaly & Zakaria (2018) and Zhang et al. (2018) have similarly reported superior functional scores and better range of motion in patients managed with dual plating, attributing these outcomes to early mobilization enabled by stable fixation. Early rehabilitation reduces periarticular fibrosis and joint stiffness, which are common complications in distal femur fractures.

The low complication rate in this study is also noteworthy. No cases of nonunion were observed, and implant failure occurred in only one patient. This is significantly lower than the rates reported in studies involving single lateral plate fixation. Ricci et al. (2014) identified medial comminution and lack of medial support as major risk factors for failure of locked plate constructs. By restoring medial buttress stability, dual plating effectively mitigates these risks. Holzman et al. (2016) demonstrated that the addition of a medial plate in failed lateral plate fixations resulted in successful healing of distal femoral nonunions, further reinforcing the mechanical superiority of dual constructs.

Concerns regarding soft tissue compromise and vascular insufficiency associated with dual plating have been addressed through minimally invasive techniques. Beeres et al. (2020) described minimally invasive double plating and reported preservation of periosteal blood supply with reduced soft tissue trauma. Rollick et al. (2020) specifically studied the effects of dual plating on distal femoral vascularity and found no significant compromise when performed with meticulous technique. These findings support the safety of dual plating when conducted using modern surgical principles.

The early initiation of weight-bearing observed in this study further highlights the stability offered by dual plating. Partial weight-bearing was achieved at an average of 6.5 weeks and full weight-bearing at 14.2 weeks. Early weight-bearing has been associated with improved muscle strength, joint mobility, and faster return to daily activities, which ultimately contribute to better functional outcomes (Gangavalli & Nwachuku, 2016; Steinberg et al., 2017).

When compared with other fixation options such as retrograde intramedullary nailing or single lateral plating, dual plating appears superior in comminuted and osteoporotic fractures. Gangavalli & Nwachuku (2016), emphasized that fracture configuration and bone quality should dictate fixation strategy, advocating stronger constructs in unstable patterns. Sain et al. (2019) also highlighted that dual plating should be considered in cases with medial voids and severe comminution to prevent mechanical failure.

Despite the promising results, this study has limitations, including a relatively small sample size and a lack of a control group treated with single plating. However, the consistency of findings with multiple biomechanical and clinical studies enhances the credibility of the results. Furthermore, the inclusion of real-world patients from a tertiary care center strengthens the applicability of these findings in routine clinical practice.

In conclusion, the present study supports the growing body of evidence that dual plating provides superior mechanical stability, promotes reliable fracture healing, allows early mobilization, and results in improved functional outcomes in comminuted distal femur fractures. By addressing both lateral and medial column deficiencies, dual plating minimizes complications such as varus collapse, implant failure, and nonunion. Therefore, dual plating should be strongly considered as the preferred fixation method in unstable distal femur fractures, particularly AO type 33-C2 and 33-C3 patterns.

Limitations include a relatively small sample size and a lack of a comparison group. Nonetheless, the consistency of findings with existing literature highlights the clinical relevance of dual plating in such complex injuries.

Acknowledgments

We are grateful to two anonymous reviewers for their valuable comments on the earlier version of this paper.

References

Bai, Z., Gao, S., Hu, Z., & Liang, A. (2018). Comparison of clinical efficacy of lateral and lateral and medial double-plating fixation of distal femoral fractures. *Scientific Reports*, *8*(1), 4863.

Beeres, F. J., Emmink, B. L., Lanter, K., Link, B. C., & Babst, R. (2020). Minimally invasive double-plating osteosynthesis of the distal femur. *Operative Orthopädie und Traumatologie*, *32*(6), 545-558.

Bologna, M. G., Claudio, M. G., Shields, K. J., Katz, C., Salopek, T., & Westrick, E. R. (2020). Dual plate fixation results in improved union rates in comminuted distal femur fractures compared to single plate fixation. *Journal of Orthopaedics*, *18*, 76-79. https://doi.org/10.1016/j.jor.2019.09.022

Bottlang, M., & Feist, F. (2011). Biomechanics of far cortical locking. *Journal of orthopaedic trauma*, *25*, S21-S28.

Ebraheim, N. A., Buchanan, G. S., Liu, X., Cooper, M. E., Peters, N., Hessey, J. A., & Liu, J. (2016). Treatment of distal femur nonunion following initial fixation with a lateral locking plate. *Orthopaedic surgery*, *8*(3), 323-330.

Fontenot, P. B., Diaz, M., Stoops, K., Barrick, B., Santoni, B., & Mir, H. (2019). Supplementation of lateral locked plating for distal femur fractures: a biomechanical study. *Journal of Orthopaedic Trauma*, *33*(12), 642-648.

Gangavalli, A. K., & Nwachuku, C. O. (2016). Management of Distal. *Volume 47, Issue 1, An Issue of Orthopedic Clinics*, *47*(1), 85.

Gwathmey, W. F., Jones-Quaidoo, S. M., Kahler, D., Hurwitz, S., & Cui, Q. (2010). Distal femoral fractures: current concepts. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*, *18*(10), 597-607.

Holzman, M. A., Hanus, B. D., Munz, J. W., O'Connor, D. P., & Brinker, M. R. (2016). Addition of a medial locking plate to an in situ lateral locking plate results in healing of distal femoral nonunions. *Clinical Orthopaedics and Related Research®*, *474*(6), 1498-1505.

Imam, M. A., Torieh, A., & Matthana, A. (2018). Double plating of intra-articular multifragmentary C3-type distal femoral fractures through the anterior approach. *European Journal of Orthopaedic Surgery & Traumatology*, *28*(1), 121-130.

Jazrawi, L. M., Kummer, F. J., Simon, J. A., Bai, B., Hunt, S. A., Egol, K. A., & Koval, K. J. (2000). New technique for treatment of unstable distal femur fractures by locked double-plating: case report and biomechanical evaluation. *Journal of Trauma and Acute Care Surgery*, *48*(1), 87.

Jiamton, C., & Apivatthakakul, T. (2015). The safety and feasibility of minimally invasive plate osteosynthesis (MIPO) on the medial side of the femur: a cadaveric injection study. *Injury*, *46*(11), 2170-2176. https://doi.org/10.1016/j.injury.2015.08.032

Khalil, A. E. S., & Ayoub, M. A. (2012). Highly unstable complex C3-type distal femur fracture: can double plating via a modified Olerud extensile approach be a standby solution?. *Journal of Orthopaedics and Traumatology*, *13*(4), 179-188.

Martinet, O., Cordey, J., Harder, Y., Maier, A., Bühler, M., & Barraud, G. E. (2000). The epidemiology of fractures of the distal femur. *Injury*, *31*, 62-94. https://doi.org/10.1016/S0020-1383(00)80034-0

Metwaly, R. G., & Zakaria, Z. M. (2018). Single-incision double-plating approach in the management of isolated, closed osteoporotic distal femoral fractures. *Geriatric orthopaedic surgery & rehabilitation*, *9*, 2151459318799856.

Park, K. H., Oh, C. W., Park, I. H., Kim, J. W., Lee, J. H., & Kim, H. J. (2019). Additional fixation of medial plate over the unstable lateral locked plating of distal femur fractures: a biomechanical study. *Injury*, *50*(10), 1593-1598. https://doi.org/10.1016/j.injury.2019.06.032

Rajasekaran, R. B., Jayaramaraju, D., Palanisami, D. R., Agraharam, D., Perumal, R., Kamal, A., & Rajasekaran, S. (2019). A surgical algorithm for the management of recalcitrant distal femur nonunions based on distal femoral bone stock, fracture alignment, medial void, and stability of fixation. *Archives of Orthopaedic and Trauma Surgery*, *139*(8), 1057-1068.

Rajasekaran, R. B., Jayaramaraju, D., Palanisami, D. R., Agraharam, D., Perumal, R., Kamal, A., & Rajasekaran, S. (2019). A surgical algorithm for the management of recalcitrant distal femur nonunions based on distal femoral bone stock, fracture alignment, medial void, and stability of fixation. *Archives of Orthopaedic and Trauma Surgery*, *139*(8), 1057-1068.

Ricci, W. M., Streubel, P. N., Morshed, S., Collinge, C. A., Nork, S. E., & Gardner, M. J. (2014). Risk factors for failure of locked plate fixation of distal femur fractures: an analysis of 335 cases. *Journal of orthopaedic trauma*, *28*(2), 83-89.

Rollick, N. C., Gadinsky, N. E., Klinger, C. E., Kubik, J. F., Dyke, J. P., Helfet, D. L., & Wellman, D. S. (2020). The effects of dual plating on the vascularity of the distal femur. *The Bone & Joint Journal*, *102*(4), 530-538.

Sain, A., Sharma, V., Farooque, K., & Pattabiraman, K. (2019). Dual plating of the distal femur: indications and surgical techniques. *Cureus*, *11*(12).

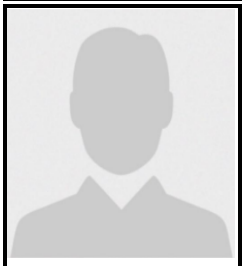
Sanders, R., Swiontkowski, M. A. R. C., Rosen, H., & Helfet, D. (1991). Double-plating of comminuted, unstable fractures of the distal part of the femur. *JBJS*, *73*(3), 341-346.

Steinberg, E. L., Elis, J., Steinberg, Y., Salai, M., & Ben-Tov, T. (2017). A double-plating approach to distal femur fracture: a clinical study. *Injury*, *48*(10), 2260-2265. https://doi.org/10.1016/j.injury.2017.07.025

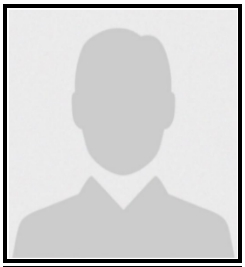
Zhang, J., Wei, Y., Yin, W., Shen, Y., & Cao, S. (2018). Biomechanical and clinical comparison of single lateral plate and double plating of comminuted supracondylar femoral fractures. *Acta Orthop Belg*, *84*(2), 141-148.

Zhang, W., Li, J., Zhang, H., Wang, M., Li, L., Zhou, J., ... & Tang, P. (2018). Biomechanical assessment of single LISS versus double-plate osteosynthesis in the AO type 33-C2 fractures: a finite element analysis. *Injury*, *49*(12), 2142-2146. https://doi.org/10.1016/j.injury.2018.10.011

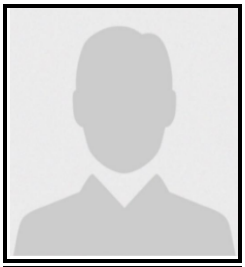
Biography of Authors



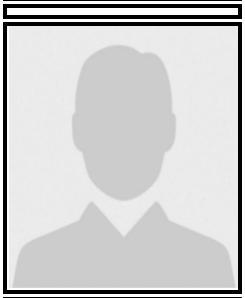
Dr Muni Sankar Reddy M
Assistant Professor, Department of Orthopaedics, Balaji Institute of Research and Rehabilitation for the Disabled (BIRRD) Trust Hospital, TTD, Tirupati, Andhra Pradesh, India
Email: sankarmbbs23@gmail.com



Dr Jishnu J
Associate Professor, Balaji Institute of Research and Rehabilitation for the Disabled (BIRRD) Trust Hospital, TTD, Tirupati, Andhra Pradesh, India
Email: itsmejishnu.j@gmail.com



Dr Avinash Bajjuri
Assistant Professor, Department of Orthopaedics, Balaji Institute of Research and Rehabilitation for the Disabled (BIRRD) Trust Hospital, TTD, Tirupati, Andhra Pradesh, India
Email: avinashbajjuri@gmail.com



Dr Venugopal S M (corresponding author)
HOD & Professor, Department of Orthopaedics, Balaji Institute of Research and Rehabilitation for the Disabled (BIRRD) Trust Hospital, TTD, Tirupati, Andhra Pradesh, India
Email: shring31@gmail.com